Feminising Science: linking theory and practice

by

E. Anne Kerr

PhD, University of Edinburgh, 1995

Table of Contents

Part 2: Empirical Exploration

Appendices a-t

Abstract

In this thesis I propose a practical framework for a feminist science by seeking to ground feminist theories about science in an understanding of the practice of science. There are three inter-linking aims. The first aim is to develop an understanding of how the practice of science is gendered. The second aim is to relate feminist epistemologies of science to this understanding of gender and science, and to suggest a 'best version' of a feminist science. This is then built upon in the third aim, namely, to suggest feminist strategies for changing science. These issues are explored further in two empirical studies which investigate experiences and perceptions of the next generation of scientists (undergraduate science students) and of women who have practiced, or are practicing, science, and who are sympathetic to feminism.

Part 1 reviews feminist literature that addresses the position of women in science, the relationship between gender and science, and feminist epistemologies of science. I identify, and explore empirically in Part 2, limitations in the various theories. These fall under two main headings. First, the relationship between male domination of science and masculinity, focusing in particular, on the social construction of masculinity within science and differences in scientific practice. Second, I investigate the gap between theory and practice in feminist epistemologies of science, covering four main issues: the role of the individual feminist scientist within the scientific community; the tension between relativism and objectivism in a feminist methodology; the organisation of a feminist science; and the relationship between a feminist scientific community and the wider society.

I argue that science is a male domain. Shared masculine values and characteristics amongst scientists preserve a sense of community and cooperation. Women are variously isolated and marginalised from the core male scientific communities. The gendering of science cannot be solely attributed to male psychological needs, but is related to the role of science in the political economy. Methodological practice is also dictated by the interests of those who fund and regulate science, and by scientists' professional interests.

This suggests that any practical framework for a feminist science must recognise that societal, organisational and methodological change are interdependent. Bringing women into science, and challenging the male networks of power within and outwith science, is fundamental to establishing a feminist scientific community and promoting methodologies compatible with feminist politics. Finally, I argue that the tension between objectivism and relativism might be viewed as creative when empirical investigations are tempered with community reflexivity.

Declaration

Except where specific reference is made to other sources, the work in this thesis is the original work of the author. It has not been submitted in whole or in part for any other degree.

E. Anne Kerr

Acknowledgments

I would like to thank my supervisors Dr Wendy Faulkner and Dr Liz Bondi for their invaluable help and advice throughout the preparation of this thesis. Thanks also to all of the people who I interviewed, especially those who provided additional guidance during my fieldwork and writing up. This project could not have been completed without the financial assistance provided by the Economic and Social Research Council, in particular an additional grant for fieldwork in North America, for which I am very grateful. Finally, I am thankful for the support given to me by my family and friends, and especially grateful to Brian for his patience and optimism.

Chapter 1 Introduction

1.1 Androcentrism and Sexism in Science

In the UK and USA scientists are predominantly male, particularly in the so-called, 'hard sciences' of physics and chemistry.[1] Despite recent government efforts to encourage more women into science, the association of science with masculinity prevails. The majority of women tend to feel ignorant, even frightened, of science. Those that do try to become scientists often encounter sexism from teachers and peers, or find it difficult to cope with the culture of science, and leave. This leads to a progressive decline in the number of women scientists towards the top of the employment hierarchy.

Sexism of these kinds are not the only problems with science. The topics studied in science have also be criticised for being part of a masculine agenda. In this sense scientists can be accused of androcentrism. Science has been criticised, for example, for failing to adequately research subjects important to women's lives. Furthermore, scientists have contributed some notorious theories in support of sexist ideology, notably women's alleged biological need to 'home make' and remain uneducated. Such theories are not confined to history, but have reemerged, albeit in a different guise, in the new science of sociobiology.

[1] Throughout this study I am focusing on science in the UK and USA. Science in Anglo Saxon countries does seem to be more male dominated than in other countries. By 'science' I therefore mean modern Western industrialised natural science. This does not imply that I consider other cultures' knowledge, or the social sciences, non-scientific - but that I am limiting my exploration of science to the most problematic area- natural sciences - and wish to avoid global generalisations about women and science. I am also focusing on the scientific investigation of the natural world. This tends to excludes engineering and technology, although I recognise that there is not always a clear distinction between science and technology, and at times my critique of science brings in engineering.

A further problem with science is the historical association between the characteristics of scientific investigation - rationality, objectivity, intervention - and those of masculinity. There is a corresponding association between femininity and emotionality, subjectivity and passivity. Feminist critics of science have argued that the methods of science reflect masculine values.

1.2 A Feminist Science

Constructing a feminist critique of science is not the end point of feminists' involvement in science. A new agenda follows from such criticism. Science, after all, is too important to be left to men. Feminists have therefore asked, first, how do we eradicate sexism in science? There is clearly a need to challenge the male domination of science. The most basic principle of feminism is equality. However, getting more women into science does not necessarily mean that the topics and questions of science, or the guiding principles of investigation, will change. These may well remain androcentric. A second question for feminists therefore arises. How can androcentrism in science be exposed and combated? A third, and perhaps most important, question is what kind of science would emerge?

The answer to these questions concerns the nature of a feminist science, or what I have chosen to call the *feminisation of science*. I have deliberately chosen the term feminisation, because it combines what I see as the three main issues involved with the notion of *moving towards* a feminist science: getting more *females* into science; making science more *feminine*; and making science more *feminist*. There is no simple strategy for meeting each of these goals. Nor is it clear how these three aspects of feminising science might interact.

1.3 Problems in the Feminist Critique and Theories of Science

I share feminists' concern with the male domination and androcentrism of science. I also recognise the need to combat sexism and to think about a feminist science. Nevertheless, I have several concerns about the current feminist critique and theories of science which have led me to conduct this study.

There are a number of problems in the feminist analysis of science. The first is the alienation of women scientists from many of the feminist arguments. There is a divide between women in science, including many of those who are active in encouraging more women into science, and feminist critics of androcentrism in science, many of whom now come from outside of science.[2] The former group are hostile to the suggestion that science is an intrinsically masculine pursuit. Women scientists often argue that science is neutral and unbiased and are at pains to stress that their approach to science is no different from men's. Many feel that feminists do not understand how science is practiced. Some perceive an overemphasis on the life sciences in the feminist critique, and argue that the physical sciences are not androcentric because they deal with inanimate objects. The hostility is understandable given that the argument that science is masculine has often been used to exclude women. For their part, the feminist critics are frustrated by women scientists' failure to recognise the fundamentally political nature of science. Feminist critics argue that there is no neutral position in science and strive to show how masculine values permeate scientists' approach. Women scientists are seen to be 'taken in' by the philosophy of objectivity which maintains scientists' powerful position as generators of truth and fact in today's society.

[2] The original feminist critics of science were mainly biologists. Now some of these critics have moved into the social sciences. Other critics and theorists come from a social science or philosophical background.

I find myself caught between the two 'sides' of this divide. On the one hand, as a physics graduate, I appreciate women scientists' hostility to the notion that science is masculine. Of course women can do science 'just as well' as men. Just because the values of science have been labelled as masculine in the past, there is not necessarily any literal association in the practice of science. I am uncomfortable with critics' use of psychoanalysis to explain men's 'need' for control, for example. The essentialist overtones in claims that science is masculine are undoubtedly problematic. For me too there is the problem of relativism when treating science as socially constructed. What is the role of nature in such a science? Surely science reflects nature to different degrees of accuracy? On the other hand, I agree with feminist critics when they note the pervasive association of masculinity with science. I also agree that the methods of science are never neutral, and may well show a masculine bias. Scientists' claim to the truth of nature must also be understood in the context of their prestigious role as experts in society, a role which they are likely to be unwilling to give up.

Whilst the initial theorists were feminist scientists, feminist theorists of science are no longer drawn solely from the scientific community. A new type of theory has now emerged - feminist epistemology of science,[3] the roots of which are in mainstream philosophy and epistemology. This has resulted in a highly abstract theoretical approach to the question of a feminist science which women in science (and many others outside of philosophy) tend to find difficult to relate to the practice of science. In my view there are two main issues behind this gulf between theory and practice: first, there is a lack of clarity about the meaning and nature of a feminist science; and second, the theory of a feminist science is too abstract and without sufficient consideration about how to operationalise a feminist science in practice.

[3] At its most basic epistemology means theory of knowledge. Feminists, and others, have argued that this should extend beyond the narrow confines of philosophical discussion of logic, and include social criteria for judging valid claims to knowledge.

In relation to the first problem of lack of clarity, it is unclear whether a feminist science would require more women scientists, and if non-feminist women and men would be able to practice such a science. It is also unclear what values such a science would embody. Would a feminist science involve so called feminine principles of emotion and connectedness, the opposite of the supposedly masculine values of rationality and separation, or would feminists seek to challenge these distinctions and move towards a gender-neutral science? Are there various feminist sciences, with different feminist methodologies, and if so, which ones are the 'best'? Furthermore, what criteria do we use for selecting the 'best' feminist methodologies?

In relation to the second issue of operationalisation, the question of whether the notion of a feminist science is purely abstract also arises. Is there a feminist science in practice today? Could it be extended? In my view feminist theory is also ambiguous about the relationship between a feminist science and mainstream science. I argue that clarity about the role of a feminist science in changing science *from within* the existing scientific institutions is essential.

In my view these uncertainties are a feature of the problem of translation - both across disciplinary boundaries, and between theory and practice. This is captured in, what is at this stage, my deliberate ambiguity in choosing the term *feminising science* which highlights the role of women, the feminine gender and the nature of feminism in a feminist science, in addition to the processes of moving towards a feminist science.

These disciplinary divisions, in addition to the gap between theory and practice, are reflected in the literature about women, gender, feminism and science. Those women scientists concerned with encouraging more women into science, and with improving women's position in science, are associated with what I call the 'women in science' literature. This deals with studies of women's place in science, many of which are statistical, and strategies for combating sexism. The second body of literature concerns gender and science. This was originally developed by feminists in the biological sciences, and is concerned with understanding how the methodologies and content of science are androcentric. Although initially strongly anti-essentialist, more recently psychoanalytic theories, some of which adopt an essentialist position, have been adopted to explain why certain methodologies in science are masculine. The third literature concerns feminist epistemology and is produced largely by feminist philosophers. Psychoanalytical theories have also been adopted in some of these theories, notably in the Marxist standpoint theories. Postmodernist concerns arise here too, which for me raises questions about the social construction of scientific knowledge, and the place of nature therein.

Although the concerns in these literatures clearly overlap, they address different agendas, and are relatively distinct. Thus the potential for feminising science is seriously reduced. It appears that women scientists, feminist critics of science, and feminist philosophers, are not sufficiently united to achieve meaningful change in science. The danger is that women will continue to be encouraged into science but will not question the content of scientific knowledge, or challenge the methodologies of science. If this happens science is likely to remain androcentric.

1.4 Linking Theory and Practice

My overriding concern in this thesis is to develop a practical framework within which it is possible to start building a feminist science, that is I seek to clarify the features involved in feminising science. I believe that this requires feminist criticisms and theories of science to be grounded in the practice of science. I hope to take a fresh approach to women, gender, feminism and science, by starting from the perspective of scientists' practice: how is this gendered, and what does a feminist science mean in practice? Answers to these questions require a deeper understanding of how gender relations affect scientific practice, and how particular methodologies come to be associated with masculinity. And we need to think in practical terms about what a feminist science might look like. I would argue that the epistemological basis of theories about a feminist science must also be challenged in order to promote more practical, and less utopian, strategies for change. Moreover, the agenda of women in science must be recognised by feminist critics and theorists and their alienation from the feminist critiques and theories addressed.

I therefore have three main aims:

1. The first is to develop a better understanding of how gender relations shape the practice of science by synthesising the feminist critiques of science and women in science literature with the experiences and perspectives of current and past feminist practitioners of science, in addition to those of the next generation of scientists: today's science students. This will in turn provide a practical basis for change.
2. My second aim is to explore what a feminist science might look like by combining this first step in my analysis with the feminist epistemologies of science and the experiences and perspectives of feminist practitioners and students. This is with the intention of identifying the 'best version' of a feminist science. My criteria for 'best' are based on my commitment to a workable version of a feminist science which can be promoted from within the existing scientific institutions, that is one which links theory and practice. At the same time, practicality must not be at the expense of radicalism.

3. My third and final aim is to provide pointers to practical strategies for change, building on these first two aims. This concerns changes in science education as well as wider changes to the organisation and practice of science.

1.5 Research Design and Outline

There are three main strands to the research design I adopt to meet the aims outlined above.

The foundation of this thesis is an analysis of the feminist critique of science and alternative feminist theories of science, with reference to the practice of science. In Part 1 I examine the three bodies of literatures outlined above, in accordance with my first research objective. Chapter 2 deals with the (largely) liberal feminist analysis of women in science. The implicit understanding of scientific practice in the laboratory as neutral and objective, and so distinct from social relations within science, is challenged in Chapter 3, where I explore the feminist critique of the effect of gender on the aims and objectives, methodology and discourse of science. In Chapter 4, I investigate the feminist epistemologies, focusing in particular on standpoint theories, postmodernist criticisms, and feminist empiricism. In Chapter 5 I draw together the main themes in my treatment of these three literatures, to develop a clear assessment of the main areas of difficulty in translating these theories into the practice of a feminist science.

Second, in Part 2, I tackle these obstacles empirically. This is based on interviews with two groups of respondents. First, I interviewed women scientists sympathetic to feminist aims. I include feminist critics of science with a science background in this group. These respondents share experience in science and an interest in a variety of aspects of feminism: from promoting women in science to developing a feminist science. I argue that these women have a privileged insight into feminism, gender and science, not only because they are women in a male dominated environment, but because they are feminists involved in a pursuit commonly associated with masculinity. I sought a thorough understanding of how science works, women's place in science, and how science is gendered. I also wanted to know how these women wanted science to change, and their assessment of the feminist epistemologies. Second, I interviewed science students, partly in order to understand more about how science education might change to meet the aims of feminism, and partly because I felt they might have a different perspective from that of the practitioners, on the issue of how science is gendered and on the nature of a feminist science, which might nonetheless prove useful.

Finally, in Part 3, I synthesise my preliminary analysis of the literature with my empirical findings and address the three aims outlined above. I attempt to clarify the gendered nature of science, plus the processes of feminising science and the nature of a feminist science, by linking theory and practice.

Chapter 2 Women in Science

2.1 Introduction

In this chapter I consider briefly women's status in scientific institutions.[4] I address women's position in the formal structures of science, in particular the employment hierarchy and disciplinary boundaries. In addition, I consider social relations in science more broadly, including informal criteria which operate to limit acceptable practice and interaction within the community of scientists. Finally I explore the reasons for women's lack of power in science, and strategies adopted by women and feminist scientists to remedy the situation. What insight does this gives to how the practice of science is gendered and how might it contribute to a practical framework for the feminisation of science?

I use material from two resources in this review. First, I use statistical quantitative material provided by government commissioned research. For example, in the USA the National Science Foundation carries out research into the position of women in science every two years (NSF, 1990). It is important to note that, in the past decade or so, governments' concern about women in science, both in the UK and USA, is motivated by concern about falling numbers of scientists in general (NRC, 1994; Office of Science and Technology Working Paper, 1993, 1994). This implies that women are seen as an untapped resource only when the number of potential male scientists is significantly depleted. Governments' attention to women in science is not, therefore, a sign of any substantial increase in concern about equality and should be treated with skepticism. As recent history following World War 2 shows, women's co-option into male occupations tends to end when the male labour force is replenished.

Other material on women in science comes from feminist scientists themselves, some of whom have been involved in government sponsored equal opportunities

4 Note that this short review only gives a snapshot of the issues in the large literature on women in science.

initiatives such as the UK's Women into Science and Engineering (WISE). This was set up in 1984 by the Equal Opportunities Commission and The Engineering Council to encourage women and girls into science and technology. Other research networks also exist, such as Gender And Science And Technology (GASAT), which draws on academia and public sector research from the Equal Opportunities Commission and includes scientists and social scientists amongst its membership.

2.2 Women's Employment in Science

Women are under-represented in the hierarchy of science, and particularly in the physical sciences. There is a wealth of information on this topic, although information is often subject-specific (eg physics) and difficult to compare (Billard, 1992). More comprehensive information is available from the USA than the UK. Note that comparison between sets of statistics is not always possible given their format by subject and country. I therefore use what statistics are available, selectively, to illustrate my point.

The main concerns around women's place in the employment hierarchy are the vertical and horizontal segregation of women in scientific professions, both in industry and in universities (Hornig, 1984). This covers subject area, position, salaries, and promotion rates. Publication rates and funding success of women in science are also of relevance. I will concentrate on the employment of women in science as more information is available. I also include a brief discussion of the numbers of men and women taking science qualifications at various stages in education.

The numbers of girls doing science at school is low (see Kelly, 1981, 1987; Harding, 1986). The proportion of girls studying science decreases as they get older, dropping dramatically around adolescence. This is particularly acute in the so-called 'hard sciences' of physics and chemistry. The main explanation for this, put forward by women writing in this area, is gender socialisation (see Kelly, 1987). They argue that from births girls are discouraged from being assertive and inquisitive about their environment. The toys girls are given are intended to socialise them for housework and child care, whereas boys are given toys that involve building and working with their hands. Once in school there is evidence available indicating that teachers do not direct science or math's education at girls; they use examples more familiar to boys and interact more with boys in the class. Text books have also been shown to contain mostly male scientists and only a few women. Although many of these issues are now well known, and steps have been taken in education to encourage more girls into science, and reduce the blatant sexism of textbooks, there are still a minority of girls in science classrooms.

Because of this some argue that the problem is deep rooted in society. Perhaps gender socialisation is not the only explanation for why girls do not do science. There is some evidence to suggest that girls approach problems differently and have different attitudes to what counts as important questions in science (see Kelly, 1987). Although this may also be socially shaped there is the possibility that psychological differences between boys and girls are also involved. This will be explored further in Chapter 3.

Whatever the reason for girls' alienation from science, the numbers decrease as girls go into further education, particularly in physics. As girls progress through university a significant number drop out, or do not take science jobs on graduating. Very few go on to do postgraduate work or to become researchers and lecturers in academia. Over all fields in the UK the proportion of university staff members who are women is less than 50% and decreases further up the employment hierarchy. For example, in the academic year 1992-93 women university staff members were 42% of the total, compromising 26% of all lecturers, 11% of all readers and 5% of all professors (Powney, 1994). The situation is even worse for women in science: for example, in 1990 the total number of women in university science posts was 2106 which is approximately 15% of the total university science staff (Department of Employment, 1990). Inequalities in the hierarchical distribution are also evidently more marked in physics: eg only two women hold Chairs of Physics in the UK (Rose, 1994, Irwin, 1994).

There is also horizontal segregation, with more women in the life sciences than the physical sciences: 24% of the membership of the Institute of Biology were women in 1992, compared with a 13% membership of the Institute of Chemistry in 1991 and a mere 4% in the Institute of Physics in 1990 (Packer, 1993).

More detailed statistics are not yet available for the UK, unlike the US, although the EC has recently commissioned research into the position of women in science in the Community (SPSG, 1994). The National Science Foundation in the US produced the following information about women in science in the US (NSF, 1990). They found that, despite rapid growth in the numbers of women in science between 1978 and 1988, women are still a minority in science and engineering employment, especially in the physical science fields as opposed to the life sciences. For example, in 1987, 33% of women in science were in life sciences as opposed to 8% in physical sciences. (The remaining 59% were in the social sciences.) Women are also less likely to hold tenure (permanent posts in the USA) than men, or to hold full time Professorships. For example, in 1987 approximately 36% of women with science PhDs were tenured, compared to almost 60% of men with science PhDs. The NSF also found that women have higher rates of unemployment and earn lower salaries at all levels of professional experience (NSF, 1990, pvii). The median annual salaries reported by women with science PhDs in 1987 averaged 79% of those reported by men with science PhDs. Finally, women experience more underemployment than men (ie working involuntarily in part-time as opposed to full-time employment or outside of science and engineering).

I would argue that the male domination of science is an important feature of the wider relationship between gender and science. It prompts questions about how this male domination impacts on the content of scientific knowledge, and the methodologies adopted in science. For example, do men have different priorities in research? These questions will be considered further in Chapter 3. I now address ways in which the male domination of science has been challenged. This is clearly important when discussing how to develop a practical framework for a feminist science since, as I have already argued, getting more women into science is one of the three issues in the feminisation of science.

The main policy recommendations for how to combat this situation seem to involve encouraging girls and women to study science at school and college; encouraging employers to recruit women; and establishing better child care facilities or even job-sharing arrangements (MacRae et al, 1991). Others have argued for more career development courses for women and the placing of responsibility and accountability for Equal Opportunities Policies at senior management levels (Skidmore, 1992). In addition it has been argued that women should be better represented on interview panels, committees and at conferences (MacRae et al, 1991).

However such programmes and initiatives have had limited success. In one study MacRae et al (1991) examined the policies and practices of ten major UK companies renowned for their good record in equal opportunities for women scientists and engineers. There were several steps in companies' policies: schools liaison, graduate recruitment, career progression and retaining women scientists and engineers. I will focus here on the successes and failures of graduate recruitment and career progression as the information is most relevant to my interest in women in science. In the case of graduate recruitment the authors found:

> despite the efforts which companies put into the development and implementation of equal opportunities policies, success in this area could be undermined by the attitudes of individuals in positions with the power to influence recruitment decisions. Reports of bias and prejudice amongst personnel with recruitment responsibilities were made by employees in all of the companies we studied ... The position was justified by reference to women's traditional responsibility for the care of their families and to the potential conflicts between work and family commitments (MacRae et al, 1991, p100).

The authors go on to demonstrate that women are not seen to be as committed to the company as men, and that those in charge of recruitment, including women, based their decisions on this perception when deciding on whom to employ (ibid).

Women's responsibility for child care also reduce their promotion success within organisations, because it is seen by employers to mean that women will be unable to meet the high level of commitment expected (MacRae et al, 1991, p75). In other words, it was found that women were disadvantaged by the requirement that they 'put their career first'. There is little evidence, the authors argue, of any trend towards more flexible employment patterns such as job sharing and home work, and nurseries and crèches have a low priority (ibid). Companies' policies on maternity leave is still to maximise the number of hours that a person works and minimise the amount of time they take off to have a baby (ibid). In the main these policies do not entail much change in science itself. It is women who are expected to fit into existing structures and approaches in science rather than changes occurring to suit women better. For example, improved child care facilities are often seen as a perk for women; the aim of provision is still to maximise women's hours of work in science. I would argue that this merely removes the burden of child care temporarily, to allow women to function as honorary men in science. The expectation is still that child care is women's work and becomes a problem when women parents, never men parents, are employed or recruited (MacRae et al, 1991).

Much of this has parallels in other professional fields of employment such as engineering and business. The approach is also similar - to change women or their lifestyles to fit into science rather than to change science. This implies that the feminisation of science must challenge the formal structures of employment. The introduction of job sharing and paternity leave is more important than improved child care facilities as this would challenge the supposition that child care is women's responsibility. This will be discussed further in Part 2, as it turned out to be a major concern of women in science.

2.3 Women and Communication Amongst Scientists

Similar issues are raised when social relations in science are considered more broadly. Work on this topic is again USA dominated, disparate and often subject-specific. However, it is also more rich as it is invariably qualitative, and more progressive, as it is less linked to government initiatives to increase the numbers of women in science, but carried out mainly by feminists and women in, or sympathetic to, science (Abir-Am & Outram, 1987; Bindman, Brading & Tansey, 1993; Hass & Perrucci, 1984, Kahle, 1985, Rossiter, 1982). I detail women's informal position in the scientific community before moving on to consider strategies to improve this position.

Zuckerman et al (1991) call women's position in science *The Outer Circle*. They argue that the marginalised status of women is as much to do with informal networks as formal positions of employment. Women do not tend to have mentors in the way that men do (Grant et al, 1992), particularly in the physical sciences, where the numbers of women further up the hierarchy is low. Furthermore, women tend to work less with eminent mentors, whose sponsorship might bring them closer to the centre of science, and can face problems, such as paternalism, in mentoring relationships with men (ibid). Moreover, women tend to be disadvantaged through what Bielby refers to as the 'subtle nuances of everyday interaction between the male majority and the female minority' (Bielby, 1991). This can mean that all the things men take for granted in science - socialising with male colleagues; acquiring advice and information about research funding; even getting preprints of research papers (Fox, 1991) - disadvantage women.

It is further claimed that men tend to be more at ease with the prevailing style of interaction in science. Anecdotal evidence suggests that men are more comfortable with 'sticking their necks out' in science, for example 'cold phoning' a funding agency programme director for advice and information about grant applications (Barinaga, 1993, p385). Other evidence suggests that females tend to be less competitive with their peers, preferring to run research laboratories non-competitively; to work in collaborations more often; and to avoid 'hot topics' in science which are excessively competitive on an international scale. Instead women tend to prefer to adopt what has been called a 'niche' approach (ibid, p386). Cole and Zuckerman (1987) have argued that this difference in approach between men and women is due to scientist's standing in their field, not their sex. However, as I have shown in the previous section, there is a direct correlation between the male sex and success in science, which can be traced to the male culture of science, as opposed to men's greater ability at science (Burrows, 1992). This is another important feature of the gendering of the practice of science and will be highlighted by the practitioner data presented in Chapter 8.

Strategies for improving women's position in scientific communities include setting up female mentoring schemes and networks to provide support and encouragement for young women and other female peers (see Urry et al, 1992). However, this often depends on there being a critical mass of women scientists (Barinaga, 1993, p387) and therefore relies on women jumping through the institutional hurdles (alone), in both research subject and employment grade, in the first instance. Although a modest goal, this is often difficult to achieve.

As in the case of improving women's structural position in science, improving their informal position has its drawbacks. Women mentoring and networking schemes run the dangers of putting women into a ghetto in science which means not breaking into the mainstream culture, and may in fact act to perpetuate the status quo as men continue to dominate powerful positions (Appel, 1994). On the other hand, this may be seen as a first step for women to gain a foothold in science.

2.4 Conclusion

It is clear from this literature that science is male dominated numerically, and that men fit in more to the prevailing style of communication between scientists. This is explored further in interviews with practitioners. In addition, this literature implied that the structures of science, and the social relations amongst scientists should be radically challenged. Women in science are disadvantaged both formally and informally. Getting more women into science is part of the project, but must also be supplemented by organisational change. This is also part of the feminisation of science project I envision and will therefore be explored further - theoretically in Chapter 4, and empirically in Chapters 7 and 8.

However there is an important feature of scientific practice which is not discussed in the women in science literature: the 'integrity' of the scientific method is not questioned. How does the organisation of science impact on scientific knowledge? There is an implicit assumption in this literature of value free, neutral, objective scientific method, which is not affected by the sex of the scientist. In my view the social relations between scientists, including the formal arrangements around employment and publishing, cannot be isolated in this way from the knowledge scientists produce and the methodologies scientists adopt. Scientific knowledge is socially shaped, as I demonstrate in the next chapter, where the impact of the male domination of science on the entire practice of science is explored.

A radical approach to improving women's place in science involves a fundamental restructuring of science (Tobias, 1992). This would also involve changes in scientific practice in the laboratory and in publishing. To achieve these changes a more comprehensive picture of how science, including research practice, is linked with gender, is necessary. I will now consider the feminist critique of science as a starting point for building such a picture.

Chapter 3 Science as Masculine

3.1 Introduction

In this chapter I review the feminist critique of the masculinity of science. This extends beyond the last chapter's focus on the organisation of science and deals with how the content of scientific knowledge, and the methodologies of science, are gendered. The relationship between the male domination of science and the masculinity of science is also discussed.

It is important to note that there are different meanings of masculinity within feminism. An essentialist position is taken in radical and cultural feminism: male behaviour is seen as being determined by male sex (Daly, 1978; Dworkin, 1981; Firestone, 1971). In liberal feminism, masculinity is seen as a stereotypical role which is encouraged through gender socialisation (Friedan, 1963, Oakley, 1972; see also Mitchell & Oakley, 1986; Franklin et al, 1991). Marxist/socialist feminists have used Lacanian and object-relations psychoanalysis to explain gender (Chodorow, 1978; Eichenbaum & Orbach, 1984; Gilligan 1982; Mitchell, 1974).

There are various criticisms of all these approaches. The first is that each over emphasises the influence of one particular factor: biology, society or psychology. In addition, there are problems with generalisation about differences between men and women, and other social differences, eg class and race (Segal, 1987; Connell, 1983, 1987). Another approach to theorising gender is the argument that the dichotomy between sex as biological and gender as cultural is itself a product of 'masculinist' thinking. It may be that 'compulsory heterosexuality' is promoted by such dichotomous thinking (Butler, 1990). Instead we could view both sex and gender as cultural products because the very act of distinguishing between male and female infants at birth is cultural. However, this brings us full circle, as yet another critique of this position is that to attribute everything to culture and deny nature is simplistic and, at worst, arrogant. The uniqueness of women's biological role as the bearer of children, for example, can be used to critique this over-emphasis on the cultural construction of gender. Moreover, the lack of subjecthood implied by this view of gender and sex as purely cultural products is politically problematic for feminists seeking to grant women agency which has so long been denied to them (Benhabib, 1990; Di Stephano, 1990; Hartsock, 1984).

The problematic nature of the notion of gender is an important aspect of my argument in this thesis and one which I intend to trace throughout the next two chapters. As I shall show, the feminist critique of science incorporates these issues and tensions.

In sections 3.2 and 3.3 I outline the background to the feminist critique of science. I explore the radical science movement and the more academic sociology of science, in particular, sociology of scientific knowledge (SSK). This is in order to meet three main aims. First, I introduce the terms and issues which come to be important in the later feminist critique. The links between science and the wider economy, the values shaping scientific knowledge, the culture of science and the relationship between science and the wider society are particularly important themes. Second, I emphasise the lack of gender sensitivity in the male dominated radical science movement and sociology of science, and thus establish the need for a feminist analysis. Finally, I draw attention to some important tensions which have been inherited by the feminist treatment of science, especially that between relativism and objectivity.

I then explore two complementary feminist critiques: section 3.4 addresses the role of gender in scientific methodology and discourse; and section 3.5 the science of gender difference (or sex difference as it is usually thought of in science). In section 3.4 I focus on how scientific methodology, especially objectivity, is gendered. I then discuss the more contemporary feminist critique of scientific discourse. The role of rhetoric and its relation to practice is a central concern of both sections. In section 3.5 I consider one feminist critique of the science of sex difference in detail, before moving on to explore more general themes in the feminist treatment of the science of gender. This is a major part of the feminist critique of science and particularly important in this case because of its emphasis on the construction of sex and gender. There are two purposes of this section: it provides concrete examples of how science in practice is gendered; and it provides a basis for further consideration of the connections between ideology and practice.

In section 3.6 I explore the reaction inside the scientific community, amongst women scientists, to the critique of masculinity and science advanced by feminists. This is in an attempt to start to understand the disjuncture between feminist criticisms of science and the dominant view amongst scientists (and indeed the wider public). Understanding the gap between the perspectives of women in science and feminist science critics gives a valuable insight into how science functions in practice, and so it is an important aspect of developing a practical framework for a feminist science.

3.2 The Radical Science Movement

The radical science movement arose in the 1960s, as a result of growing discontent amongst scientists and others about their role in war and pollution (Rose and Rose, 1969; 1976 a & b). Pressure groups were formed, and laboratories and factories occupied, in Europe and the USA, as well as Japan and Australia. Writing in 1976 Hilary and Steven Rose argued that the time had come to,

> develop a theoretical perspective which would enable them to articulate the links between struggles in the different areas ... it was time to move beyond the early pragmatic phase to a stage at which the contradictions present within science could be seen as part of a generally revolutionary perspective (Rose and Rose, 1976a, pxiv).

The critique of science that the movement sought to articulate was to focus on the ways in which science and technology are part of capitalism and imperialism, and to offer more radical alternatives. This required an understanding of the political economy of and 'ideology of/in science' (Rose and Rose, 1976b, pxv).

The aspects of this critique of existing capitalist science most relevant to the feminist critique that would later develop are, first, the links between science and 'systems of domination' - capitalism and imperialism (Rose, 1994, p3) - and second, the dialectic between ideology and science, especially on neutrality in science.

Theorists in the radical science movement, amongst them Steven and Hilary Rose, argued that science is part of the system of production and social control in capitalist and imperialist economies,

> it has a productive *and* an ideological role, the understanding of which is confused by reference to the 'scientific community' as an undifferentiated whole. In fact this community is divided into, on the one part, the majority of alienated, proletarianised *scientific workers*, and on the other, the tiny minority of the elite carriers of bourgeois ideology, the *scientists* (Rose and Rose, 1976a, pxvii, emphasis in original).

Here ideology is produced for the purposes of social control. However the concept of ideology proved slippery ground for theorists. The Lysenko affair and the Soviet cultural revolution of the 1930s, which caused bitter disputes between scientists and non-scientists in the Communist Party in the UK, was a problematic backdrop (see Rose, 1994, p6 for more details). The movement of the 1970s split over the concept of ideology, some holding to the old Marxist assumption the science (including Marxism) was above ideology. Others, like the Roses, argued science was shaped by ideology. They argued that science is, by its very nature mystifying, and designed to enter the consciousness of the worker to obscure the contradictions of capitalist production (Rose and Rose, 1976a, pxviii-xix)

A good example of the position that science is permeated by ideology is provided by Steven Rose in his chapter entitled, 'Scientific Racism and Ideology: The IQ Racket from Galton to Jensen' in *Political Economy of Science and Technology*

(Rose in Rose and Rose, 1976a, Chapter 7, pp112-141). Here, and in Chapter 6 by Steven and Hilary Rose, a critique of biologism is developed,

> Biologism takes one part of the explanation of the human condition, excludes all other considerations, and announces that it has *the* explanation for aggression and altruism, war and class struggle, love and hate. Attempting to change the human condition is then perceived as an absurd opposition to both our natural selves and the natural world ... Biologism, for all its apparent scientificity, is thus mere ideology, the legitimation of the *status quo* ... In biologism reductionism, which was originally simply a powerful tool for examining specific problems under rigorously defined conditions, became saturated with ideology. Reductionism is thus part of the ideology *of* science, and in so far as the theories serve specific dominant classes, also legitimises and obscures ideology *within* science (Rose and Rose, 1976a, pxx).

As an illustration of this last point Rose takes issue with all aspects of the scientific claims that IQ is linked to race and class. He criticises the ideas that:

> (1) There is a thing called intelligence, which IQ tests measure;
> (2) The working class, the Irish, Blacks, and Mexican Americans score lower that the middle class, the English, and white Americans;
> (3) Studies on the hereditability of IQ with the White population, based largely on the evidence of identical (monozygotic) twins reared apart, suggest that 80 percent of the variance between individuals can be parceled out as genetic, 20 percent as environmental;
> (4) For the purposes of applying these calculations to social groups, Blacks, Mexican Americans, and so on can be regarded as representing biologically defined as well as socially defined races; and
> (5) The differences between these groups are larger than can be accounted for by the 'environmental' factor, and hence are genetically based (S. Rose, 1976, p116).

Rose's main argument is that the reemergence of IQ theories in the 1970s, was a product of social and economic concerns. Defeats for white imperialism in the 1960s, as well as deepening race conflicts in the US and increasing levels of immigration in Europe, combined with the economic recession, provided the breeding ground for a renewal of scientific racism (S. Rose, 1976, p137). Intelligence was narrowly defined, from a white man's perspective, and tested via questions which reflected the interests and values of the white middle classes. Assumptions about causation ie hereditability as opposed to environment were based on limited data and unexamined presuppositions.

Here, on one side of the radical science movement, predominantly non-scientists argued that the IQ story was an example of how science is permeated by ideology, and in that sense a product of social and economic concerns in wider society. On the other side of the movement, scientists argued that the IQ saga was an example of bad, socially polluted, science, and, by implication at least, that good, ideology-free science was possible (Rose, 1994, p5).

These issues of biological reductionism and the extent of the 'ideological pollution', or the integrity of science, were to be important in a feminist critique of science, which would bring in the role of patriarchy and social control of women through gender ideology. This second argument was to be particularly relevant to a feminist treatment of science: is sexist science merely bad science? Or is all science socially constructed and if so, how do we judge between what is good and bad?

A related point of differences between some scientists and other non-scientists involved in the radical science critique was the issue of the neutrality of science. Giovanni Ciccotti, Marcello Cini and Michelangelo de Maria, in Chapter 3 of *The Political Economy of Science,* approach the role of science in productivity with Marx's theory of surplus value. They see scientists as the producers of the commodity of information and therefore alienated from their product, as are manual workers. The scientific fields which are not directly involved in producing information, the so-called 'pure sciences', are involved as the 'base' on which the information-commodity market rests through their role as generators of new languages and methods in science and as a testing area for checking new technology (Ciccotti et al, 1976, pp44-46). This clearly ties science to the capitalist economy, and therefore challenges the concept of the neutrality of science:

> the concept of neutrality is nothing more than a specific form of fetishism, which attributes an objective intrinsic property to a product of human activity

labour which actually derives from the social relationships which intervene between them (Ciccotti et al, 1976, p45).

This 'fetishism' was also seen by many in the radical science movement as playing a part in legitimating the authority of scientific knowledge in the wider society and thus legitimating sciences' contributing to ideology. As in the IQ story, when prejudices are given scientific backing and couched in scientific terminology, their potency is only increased.

In contrast, those who argued for the neutrality of science, took two main positions. The first was that whilst the overarching aims of science are to contribute to the capitalist economy, the actual practice of the scientist is removed from the concerns of capital, and is instead permeated by a moral commitment to rigorous and value-free science. The use/abuse of the resulting knowledge depends upon the wider society. In the right hands science will be liberating, in the wrong hands science will be oppressive. This remains a popular argument today, eg the view of science's relationship with the military. The second argument rests upon a distinction between pure and applied science. Here applied science has clear links to the economy, but pure science is seen as more independent and therefore more neutral. Ciccotti et al seek to challenge this argument by their insistence that pure science serves a role in the economy. However, the more indirect relationship between pure science and the economy, as opposed to applied science and the economy, is not explored. Thus a perception of pure science as more independent (if not thoroughly independent) can remain.[5]

This conflict is also relevant to a feminist treatment of science. To what extent is science neutral, and isolated from the wider society, including patriarchy? It is also important to note that the economic explanation of the lack of neutrality of science

[5] The debate about the relationship between science and technology has similar themes, eg the notion that technology is 'applied science'. A view of the two as distinct, yet evolving in parallel is favoured by some, and is perhaps a good compromise position in relation to pure and applied science.

fails to take into account patriarchy [the dominance of women by men economically, sexually and culturally] and what role this plays in the economy, in particular woman's labour which is often outwith the formal economy in unpaid domestic duties is not considered.

These disputes about ideology and neutrality were never resolved in the radical science movement. Hilary Rose argues that the balance between activism and theorising slipped too far in the direction of theory that not only alienated practicing scientists, but also alienated women and ethnic minorities. Earlier doubts about the male- and white-dominated nature of the activism magnified into doubts about the lack of proper analyses of gender and race in the radical science critique (Rose, 1994, p4).

It is important to note, however, that, although disputes about the neutrality and integrity of science were never resolved in the radical science movement, they did perform an important service in bringing to the fore issues about the relationship between science and ideology. Moreover, although the conflict between good science/bad science, the use abuse model, and social constructivism, may remain unresolved, the tensions need not be unproductive, as I shall go on to argue later.

3.3 Sociology and Philosophy of Science

3.3.1 Critique of Mertonian Sociology of Science

Prior to Kuhn the sociology, history and philosophy of science did not question the neutrality of science or the concept of progress. Robert Merton's work on the interactions between the social organisation of science and the growth of knowledge encapsulates this view of science. Barnes and Edge write:

> Robert Merton stressed the point in his pioneering work, and the important school of functionalist sociologists which followed him tended to take it for granted. This led them to explore the interactions between scientists

> themselves for evidence of the social processes which maintain order, confer rewards and recognition, and allow for the exercise of control over the content and quality of certified knowledge. Further, the Mertonian tradition emphasised the role of *academic* science as the fullest embodiment of scientific ideals and practices, and the ultimate source of cognitive authority (Barnes and Edge, 1982, p13).

Around the time of the radical science movement this view of science was also being challenged in academia, by the ground breaking work of Thomas Kuhn (1962). Kuhn's *The Structure of Scientific Revolutions* introduced the concept of normal science, which characterises routine science as puzzle-solving activity in a received tradition, or paradigm. Paradigm shifts occur when the paradigm can no longer provide a sufficient explanation of the phenomena in question, and a new and 'better' theory is developed. Although Kuhn's work was subsequently subject to detailed debate and critique of the notions of revolution and paradigm, his work marked a turning point in the sociology of science which paved the way for the emergence of a new field, the sociology of scientific knowledge (SSK).

There are two main themes to my review in this section. First, I address the social shaping of science and how this forms a backdrop for the feminist critique. I deal with sociology of science's treatment of the relationship between the culture of science and the wider culture, which involves the interaction of society and science: I then move on to consider SSK's analysis of how theory in science is 'underdetermined' by the evidence and how observation in science is theory laden; the extent to which we can speak of knowledge as socially constructed; and use of symmetry to analyse scientific knowledge claims, which brings me to the issue of relativism. My second main aim is to point out the inadequacies of the initial sociology of science and SSK theories for dealing with gender in science, to explain the need for a distinct feminist critique.

There is a vast array of different writings in sociology of science and it would be impossible for me to do it all justice here. Instead I have chosen to base my discussion around the main ideas which are of relevance to the development of the feminist critique. This initial treatment is based largely on overviews provided by Knorr-Cetina and Mulkay (eds) (1983) and Barnes and Edge (eds) (1982). I return later to a discussion of some of the newer methodologies when I reach the feminist critique of science in the 1990s.

3.3.2 The New Sociology of Science

Sociology of science deals with the social relations within science: most notably in the Mertonian tradition, with the so called 'reward system' based on *peer judgment* in the scientific funding and publication process:

> the contribution of a scientist is assessed by an "audience" of colleagues, who are potentially in a position to make use of it. If they judge it to be original and significant, allow it to be published and capitalise on it in their own work (citing the contribution meanwhile in the references to their papers) then the scientist achieves the award of recognition (Barnes and Edge, 1982, p15).

This follows from the Mertonian assumption that interactions between scientists maintain social order. Pure science, an ideal type of academic science, is the model for this analysis as opposed to more applied science (although such a distinction is problematic).

Merton identified the *institutional norms* of science as universalism, communality, disinterestedness and organised skepticism. However this was later criticised in the new sociology of science for encouraging an internalist picture of science. These norms are now considered by some to be a set of *rhetorical resources* that scientists draw upon to justify their behaviour (Mulkay, detailed in Barnes and Edge, 1982, p18).

The new sociology of science was not shackled by functionalist assumptions and felt free to investigate the knowledge claims of science. It has analysed the important *boundaries* between scientists and non-scientists, experts and non-experts, and disciplines of science. The status of the expert scientists, for example, is 'reinforced by a command of esoteric language and skills' (Barnes and Edge, 1982, p18). It demonstrated that the choice of one expert opinion over the other is not based on technicalities alone but is context dependent. Boundaries between fields show that the scientific community is not homogeneous; more informal research networks are established by small groups with similar interests -what Crane has called *invisible colleges* (Crane, 1972; Price, 1963). These informal networks are established by scientists in order to promote their interests vis a vis other competing groups. For example, preprints of papers are circulated through invisible colleges prior to publication. Information is thus circulated, and contained within, privileged groups, which have a mutually supportive relationship. In Chapter 2 I showed how these networks are often male dominated, and act to marginalise women scientists. These boundaries and networks of communication are fluid - for example at certain stages the effect of competition may be to limit communication (see Collins in Barnes and Edge, 1982). *Conventions* are established in science, and are thought of in sociology of science as products rather than determinant of action (Barnes and Edge, 1982, p70). *Closure* - choice of one scientific theory over another - is achieved through preference for the option that 'best maintained current practice and created opportunity for the extension of that practice' (Barnes and Edge, 1982, p74).

There has been a significant amount of work done in sociology of science on the role of the scientific expert in society (see, for example, Nelkin and Gillespie, Eva and Johnston in Barnes and Edge, 1982). In public disputes, such as around the siting of a nuclear power plant (Nelkin, 1982) technical expertise is utilised by both sides in the conflict. More powerful groups are better able to mobilise scientific opinion, which brings weight and legitimacy to their argument. This is a mutually reinforcing relationship - it is the authority of science in society that lends weight and legitimacy to scientific expertise. Note that this often means that women in the community are generally at a disadvantage, as they tend to be amongst the least powerful groups.

Studies of the role of scientific experts in higher levels of government and industry reveal:

> the consolidating effect of expertise on power structures has come to be widely realised ... experts are cited when they confirm prejudices and overlooked when they do not (Barnes and Edge describing Nelkin's work, 1982, p249).

Sociologists have also highlighted the role of 'scientism' (Habermas, 1971 reprinted in Barnes and Edge, 1982). Scientism is the wider use of scientific and technical terminology in society. This

> infiltration of technical expertise determines the conceptualisation of political problems, the language in which they were expressed, and the institutional forms by which decisions are reached (Barnes and Edge, 1982, p244).

The mobilisation of the scientific expert in public disputes, illustrates the privileging of scientific information over subjective experience, and the link between access to information and power. These will prove to be important themes in the feminist critique of science.

3.3.3 Sociology of Scientific Knowledge

The SSK was initially concerned with the way that *interests* construct knowledge, and took the form of two distinct schools - the Edinburgh 'strong' programme including Barry Barnes (1974, 1977, 1988) and David Bloor (1973, 1976); and the relativist school associated with Bath, a principal writer being Harry Collins (1981). Others involved in the field have subsequently developed new methodologies: for example ethnomethodology of scientific practice; discourse analysis (eg Gilbert & Mulkay, 1984) and constructivist/ethnographic studies of scientific work (Knorr-Cetina, 1981; Latour and Woolgar, 1979).

A central theme in SSK, in all its variants, is that scientific theories are never neutral or objective (Hesse, 1980). Instead, following on from an idea promoted by the philosopher Quine amongst others, theories are said to be 'underdetermined' by the evidence and assumptions on which they are based. As Knorr-Cetina and Mulkay argue this means:

> any theory can be maintained in face of any evidence, provided we make sufficiently radical adjustments elsewhere in our beliefs. This follows from the fact that no one theory can ever be extricated 'from the ever present web of collateral assumptions' so as to be open to conclusive refutation (Knorr-Cetina and Mulkay, 1983, p3).

Furthermore, observations are 'theory laden' as they involve assumptions, for example about how to make certain measurements, and depend on the theory which the experiment is designed to test in order to determine what is relevant and proper evidence. This line of analysis provides the opening for 'social factors' into sociological accounts of scientific theories and results.

Note the difference in justification for scientific knowledge being socially determined between the radical science movement and SSK. In the previous analysis the emphasis is much more on the external political and economic factors, whereas with SSK the emphasis is on the micro-level laboratory context.

The 'social factors' involved in scientific knowledge are, as with the radical science movement, a matter of debate. Bloor, for example, argues for symmetry when treating scientific claims that are considered by the scientific community to be true and those that are considered false (Bloor, 1976). This was in response to previous studies of science that sought to attribute social factors to discarded scientific knowledge, but regarded current scientific understandings as immune to social influences. In such studies social influence was equated with bad science whereas SSK treats all science as socially constructed knowledge and no value judgment is made about the validity of scientific knowledge claims.

Knorr-Cetina and Mulkay argue that this form of epistemological relativism is not to be collapsed onto judgmental relativism, which makes the additional claim that all forms of knowledge are equally valid and one cannot discriminate between different claims. However I am not convinced that the sociologists of scientific knowledge actually avoid any form of judgmental relativism. For example Barry Barnes writes:

> In arguing that all belief systems must be treated symmetrically for purposes of sociological explanation, many traditional ways of justifying belief as knowledge were incidentally undermined. It transpires that one perspective can only be shown to be preferable to another in expedient terms [as means to an end] ... Thus the epistemological message of the work could be said to be skeptical, or relativistic. It is skeptical since it suggests that no arguments will ever be available which could establish a particular epistemology or ontology as ultimately correct. It is relativistic because it suggests that belief systems cannot be objectively ranked in terms of their proximity to reality or to rationality (Barnes, 1974, p154).

The justification for each claim over another therefore 'lies within itself' and no external adjudication can take place. This appears to be judgmental relativism of belief systems; for example, different claims in science cannot be distinguished as nearer the truth or nature, which implies that we cannot value one over the other on these criteria.

Feminists generally oppose judgmental relativism. The problem of full blown relativism for feminists is, in short, that it makes it impossible to distinguish between sexist and non-sexist scientific claims. For feminists this is politically regressive. A weaker form of relativism may be more acceptable - to acknowledge that both sexist and non-sexist claims are socially constructed - however some criteria for judgment is necessary to distinguish the two and here feminists are inclined to fall back on the good science/bad science distinction, at least partially. In other words, the problem for feminists is to establish what *social factors are involved in the construction of scientific knowledge* and, at the same time, *what are acceptable criteria* against which to judge scientific knowledge. Are some social factors shaping knowledge more acceptable than others: for example, factors internal to the scientific community (background assumptions) as opposed to external factors (including ideology)? Or are some external and internal factors more acceptable than others: for example counter ideology which is anti-sexist as opposed to sexist ideology? This is explored further in Chapter 4.

A related theme in SSK is the concept of reflexivity. This is where sociologists apply relativistic concepts to their own work, leaving them to argue that theirs is only one version of events and not any more accurate or valuable (depending on the extent of their relativism) than other accounts. Again, this initially appears to be a problem for feminists: if they were to adopt a reflexive approach how would they argue that a feminist treatment of science was more accurate or valid than a misogynist one? Feminism involves a committed approach to knowledge which seeks to further equality for men and women. The issue is a political one. In their most extreme form relativism and reflexivity demand an apolitical stance. Because SSK theorists can end up saying nothing judgmental about science they can be accused of passively accepting and thus contributing to the perpetuation of the status quo.

The tendency amongst certain members to adopt 'methodological internalism' as Knorr-Cetina and Mulkay call it (Knorr-Cetina and Mulkay, 1983, p6) is worth considering further. SSK mostly deals with microscopic study of scientific practice and prioritises *how* rather than *why* scientists do and talk about science (Latour & Woolgar, 1979; Knorr-Cetina, 1981; Traweek, 1984, 1988, 1989; Gilbert & Mulkay, 1984). These theorists are generally not interested in imposing explanations for behaviour on their accounts. Internal mechanisms shaping scientific knowledge are seen as much more important and than so called external factors (Barnes & Edge, 1982, p188). By some the very existence of external social structures, eg capitalism and imperialism, which can affect scientists' work, is even rejected (for example, by Latour, 1987).[6]

[6] Note that the initial theorists were concerned with power and interests, and how these shaped science (cf Barnes, 1977, 1988), but that this strand of research did not emerge as prominent.

These two aspects of SSK scholarship - the micro level of many of these studies, and their preoccupation with description rather than explanation of scientists' practices - seem to be at odds with many more political concerns. For those in the radical science movement and for feminists, the question of why scientists do what they do seems to me to be extremely important. How much this has to do with their sex and/or gender and class and race is also a key issue. Similarly the internalist quality to much of SSK work leaves out some big questions that are important in the radical science debate and feminism. Patriarchy is a social structure central to a feminist analysis. To what extent is science immune from outside cultural influences? How does gender ideology translate into scientific theory? How does the sexual division of labour in society translate into division of labour in science and ultimately into scientific theories and results? These questions cannot be answered with a purely internalistic analysis.

Some areas of SSK are of potential importance to a feminist analysis of science. Not all theorists shy away from discussion of the reasons for scientists' actions. For example, the Marxist and so-called 'weak' school (eg Restivo, 1983) are interested in critique. Whilst their concern with the 'how' questions are still dominant, they judge their analysis by its value in explaining the reasons behind how scientists work and by how much it tells them about how to effect change (Knorr-Cetina and Mulkay, 1983, p8). A minority have looked at the wider societies' influence on science, usually in historical studies (see for example Miller, 1972; Provine, 1973; Ben-David, 1960; Shapin, 1980, 1982; Ezrahi, 1971). Barnes and Edge describe their claims:

> that the images and representations, particularly images of social and political relationships have been drawn from the surrounding context and incorporated into the culture of science; or claims that the external context has engendered variations in scientific judgment of matters of fact (Barnes and Edge, 1982, p192).

Brian Wynne has looked at how the social usage of science has affected the meaning of scientific terms and therefore the context of the science itself (see Wynne in Barnes and Edge, 1982). Barnes and Edge argue that these external contingencies often take the role of generation of ideology as opposed to 'genuinely technically applicable knowledge' generated by internal contingencies (Barnes and Edge, 1982, p194). This relates to debate about the extent and role of ideology in the radical science movement, as detailed in section 3.2.

3.3.4 The Missing Element: Gender

The gender blindness of these sociologies of science cannot be ignored. With the notably exception of Traweek (1984, 1988, 1989) who gives an account of gender in her work on high energy physics, the relationship between the sex of the scientist and the established conventions and boundaries of science are not analysed. The way that gender metaphors work in science and the association of science with masculinity also tends to be ignored, despite the concern with rhetoric. In addition, the position of the (male) scientific expert in relation to female 'non-experts' in the community is not addressed, and so there is no attempt to empower women in their dealings with experts by unmasking the contingent nature of their knowledge.

Insufficient interest in how gender relations enter into the social construction of scientific knowledge is one consequence of the SSK theorists' methodological internalism and lack of concern with explanation. Thus important questions such as, 'are certain assumptions and methodologies in science based on stereotypical notions of masculinity and femininity?' are ignored. Even those theorists who do address the wider societies' influence on science do not sufficiently consider gender.

Although radical science activists were more aware of gender than their academic counterparts, the male domination of the left, still notorious today for its machismo, and their move to abstract theorising, prevented any serious consideration of gender.

I now consider the feminist critique of science. Feminist critics seek to explore the gendered ideology and social construction of science, and tend to adopt different tools from the radical science movement and sociology of science, such as psychoanalysis. As I shall show, important analytical tools and findings in the radical science and sociology of science fields are missing from the feminist critique. There may, however, be a way to unite the three traditions, to form a more powerful critique of science, as I try to show later.

3.4 Feminist Critique: Science as Masculine

The feminist critique of science as masculine developed from the late 1970s onwards, and drew feminists from different backgrounds, including the radical science movement, the feminist movement, and academic disciplines of the history and sociology of science. By outlining different themes in the radical science movement and SSK, I do not wish to imply that the feminist critique was a linear progression from these areas. This would be a rewriting of history. Nonetheless there are several aspects to the feminist critique which share common themes with both the radical science movement and SSK. There are also differences in the feminist approach which require exploration. The purpose of drawing out these similarities and differences is to increase understanding of the feminist critique of science in terms of practice.

A central theme in feminist critiques of science, since the late 1970s and early 1980s, is the claim that science is masculine. Evelyn Fox Keller traces the origins of the term 'gender and science' to 1978 (Keller, 1994), when she wrote a paper demanding an inquiry into what she refers to as,

> [t]he historically pervasive association between masculinity and objectivity, more specifically between masculine and scientific (Keller, 1978),

and criticised both the scientific community, and philosophers and historians of science, for their failure to investigate this relation. She attributed their silence, in part, to the tenacity of the 'myth of objectivity' in science, even amongst outside critics. However, as we have seen in sections 3.2 and 3.3, those in the sociology of science who reject the 'myth of objectivity' largely ignored gender too, and the radical science movement did not provide a comprehensive approach (Rose, 1994). The male domination and/or masculinity of both these areas must be considered as potential reasons (see also Easlea, 1978, 1981; Griffin, 1984; Merchant, 1980; Haraway, 1979).

Around the same time as Keller's initial critique, other women in science were beginning to develop an interest in gender and science, notably the Brighton Women in Science Group (1980) in the UK, and various women biologists in the US (Hubbard, Henifin and Fried, 1979, 1982; Hubbard and Lowe, 1979, 1983; Bleier, 1984, 1986). Other women in science were criticising science from a feminist perspective in Canada, notably the late Margaret Benson (1982) (see also Franklin et al, 1993). A lot of this work concerns gender and sex in human biology, which I will consider in section 3.5. Nevertheless, there is a significant portion which develops a feminist critique of the methodology and discourse of science and is therefore dealt with here.

For these feminist theorists the main issue was initially the gendering of scientific objectivity, the 'sacred cow' of orthodox science. It is this critique that I consider first. I then move on to a more contemporaneous critique, which draws on this initial concern with objectivity, but is primarily concerned with how the language of science is gendered.

3.4.1 Methodology and Objectivity

The radical science movement and SSK provided feminist critics of science with a valuable insight into the social shaping of science, in particular the nature of objectivity. As I have already shown in sections 3.2 and 3.3 appeals to objectivity in science have a role in legitimating scientific information in the wider community, and play an ideological role: in maintaining the image of objectivity scientists protect their position. In addition, within science, appeals to objectivity are often used as a rhetorical device to legitimate choosing one approach over another. Scientific results are never objective but value-laden, and based on both internal and external contingencies, ie results can be influenced by social relations within the particular sub-community of science, or beyond, in the wider culture (see Savan, 1988). However, neither SSK or the radical science movement have considered how notions of objectivity may be gendered.

Feminists (see for example Hubbard et al, 1983; Bleier, 1984) have argued that natural science is not objective, but instead 'reflects the outlook and interests of its producers' (Hubbard et al, 1983, p4). This is evident in the problems that scientists consider worthy of study and in the acceptable answers to such problems. Both will be 'congruent with the implicit assumptions that form the basis of their understanding of the world' (ibid). Science has a long history of male domination: feminists have asked does this affect the science produced? There are various answers to this question, many of which seem to rely on assumptions of men sharing a world-view which differs from that of women. (The extent to which this is biological or social is not clear.) Others reject this and prefer to concentrate on the (imputed) masculinity of the actual methods of science.

Feminists have argued that science is far from neutral as the principles of scientific inquiry are 'masculine'. Fee notes:

> the liberal ideology of rational man is actually dependent on an unstated clause: that the characteristics of "man" are actually the characteristics of males, and that rational man is inextricably bound to his less visible partner, emotional woman (Fee, 1983, p11).

She outlines a series of sexual dichotomies which became evident in the new liberal philosophy of science, developed in the 19th Century:

rationality - emotionality

objectivity - subjectivity

culture - nature

public - private

truth - beauty

active - passive

selfish - selfless

MASCULINE - FEMININE

Note that Fee argues that each side of the dichotomy is dependent on the other: for example emotionality cannot exist without rationality. There is a fundamental inequality as male is privileged over female. Fee continues that this dichotomising became a essential feature in the development of rational inquiry:

> science came to be seem as necessarily male, as an essentially masculine activity (Fee, 1983, p13).

Fee thus argues that science is not masculine simply because it is male dominated, but because the fundamental principles of scientific inquiry are perceived as masculine. The perceived attributes of men are the attributes of science (ibid).

The reasons for this are not dealt with by Fee. One theorist, Ruth Bleier, suggests that the rationale behind the creation of such dichotomies was the perpetuation of the separate spheres of men and women in the mid 19th century (Bleier, 1984, p197). Bleier notes that others have suggested that these dualisms may be a product of a,

> male reproductive consciousness, expressed in the need and the struggle to displace women from their material base of power in reproductive and genetic continuity (Bleier, 1984, p198 paraphrases O'Brien, 1981).

Easlea (1978, 1981), Griffin (1984) and Merchant (1980) have addressed these issues historically. However, there is no clear and uncontested analysis of how these dichotomies came about, just a widespread belief that they are fundamental to an understanding of the philosophy associated with the emergence of modern science.

Objectivity in this feminist analysis is therefore a masculine epistemological stance that denies its own subjectivity (Bleier, 1984, p196). Furthermore, the basic dualism between masculine and feminine is unequal, with the feminine, emotional, subjective and so on being subordinate (Bleier, 1984, p198). This privileges objective, scientific knowledge over other forms of subjective knowledge. The myth of the neutrality of such knowledge minimises the criticism of such knowledge, and effectively enhances the privileged position of the scientist in the community (Hubbard et al, 1982, p3). Feminists have engaged in detailed criticism of the way the myth of objectivity encourages scientific elitism. For example Marion Lowe writes:

> The conventional view of objectivity is not simply a misconception that has occurred by chance. The rhetoric of objectivity serves to obscure the very real social and political biases of knowledge produced within universities. This knowledge is systematically more useful to the privileged than to the majority of people. It especially benefits businesses, the military and governments. However, if knowledge is seen as value-free then the question of who the knowledge serves can never arise. In fact the emphasis on objective knowledge acts to limit inquiry to topics which do not threaten the social order, since work that suggests changing the class structure or the gender or racial biases of our societies is seen as unsound (Lowe, 1993, p8).

This of course means that the producers of knowledge are limited to a supposedly apolitical group whose privileged status is maintained by their immunity from criticism on the grounds of their 'neutrality'. Hence the status quo is perpetuated.

To recap, in this analysis objectivity is labelled as at once masculine and neutral in liberal philosophy of science. Objectivity was named as a masculine trait (by male philosophers and scientists), and this was used as a justification for the exclusion of women from science. It is implied that males are more likely to exhibit masculine behaviour (be that for social or natural reasons, or a combination) which is more congruent with behaviour acceptable in science than behaviour based on feminine characteristics. This process becomes mutually reinforcing: individual male scientists perpetuate the masculine values of science just as the masculine values of science perpetuate the male domination of science. This analysis has some empirical weight: as we near the end of the 20th century the myth of objectivity is alive and well, and men still dominate science. Theirs is a privileged and protected position in the wider community which acts to maintain the status quo.

3.4.2 Keller's Work on Gender Ideology

Evelyn Fox Keller is the principal feminist critic of science who has elaborated this critique in her exploration of the role of what she calls 'gender ideology' in science (Keller, 1985, p4). Gender is socially constructed and defined as a 'label' we place on our human experience - male or female:

> gender is neither simply the manifestation of sex, nor simply an easily dispensable artifact of culture. It is instead what a culture makes of sex - it is the cultural transformation of male and female infants into adult men and women (Keller, 1994, p 81).

The way in which gender ideology works in science is rooted in what Keller calls the 'science-gender system' (1985, p8). A mutually reinforcing set of dichotomies exist, which, as above, means that

> the division between objective fact and subjective feeling is sustained by the association of objectivity with power and masculinity, and is removed from the world of women and love. In turn the disjuncture of male from female is sustained by the association of masculinity with power and objectivity, and its disjuncture from subjectivity and love. And so on (Keller, 1985, p8).

Keller is especially concerned with the subtler ways in which gender ideology manifests itself in science. Objectivity, she argues, plays a role in imposing a 'veil not so much of secrecy but of tautology' [repetition of the same idea in different ways] (1985, p12). The practices of science become immune to criticism because they are viewed as objective.

Keller's preferred tool for analysing the relation between gender ideology and science is object-relations psychoanalysis. In Chapter 6 of *Reflections On Gender and Science* (1985), entitled 'Dynamic Objectivity: Love, Power and Knowledge', she considers ways in which objectivity is linked to domination and power as opposed to love, drawing on object-relations theory to develop her point. Keller focuses on the adversarial relationship of the scientist to the object of study:

> the specific kinds of aggression expressed in scientific discourse reflect not simply the absence of a felt connection to the object one studies but also the subjective feelings many children (and some adults) experience in attempting to secure a sense of self as separate from the more immediate objects of their emotional world [primarily the mother] ... similarly the need to dominate nature is, in this view, a projection of the need to dominate other human beings; it arises not so much out of empowerment as out of anxiety about impotence (Keller, 1985, p124).

Here gender ideology in science is reflected in the individual psychology of the (male) scientist.

Rhetoric of domination and aggressive separation from the object of study has had a decisive impact on the development of Western science, according to Keller:

> Rhetoric of domination, coercion and mastery serves to select a scientific community that tends towards particular emotional and cognitive styles ... this rhetoric, internalised by that community, in turn selects for compatible scientific styles of work, methodologies, and even theories (Keller, 1985, p126).

But the role of rhetoric in scientific practice is not straightforward:

> ideological norms may be formative but they are never fully binding. In every period of scientific history, in every school of science, we can see a rich diversity of meanings and practices. In fact it would appear that where ideology makes its force felt most crucially is in the process by which some theories, methodologies and experiences are discarded (Keller, 1994, p).

Keller makes an important point here: there is a diversity of approaches in science, but the predominant approach that gets legitimated as 'good science' is one that most closely reflects the rhetoric of domination and separation.

This is illustrated in Keller's biography of Barbara McClintock (1983). Although McClintock eventually won the Nobel Prize for medicine and physiology in 1983, it took 32 years for her pioneering work in genetics to be recognised. Her complex 'jumping gene's' theory ran contrary to the received wisdom of the time of strictly organised genetic arrangements. McClintock's was a very different kind of science, one which involved a more connected relationship with the material and a humble approach based on 'letting the material speak' (Keller, 1983). Keller examined McClintock's methodology and claimed it was different from that of masculine science:

> The tenacity with which she hunted down every observable chromosomal modification, the thoroughness and rigor that accompanied her virtuoso technique ... might lead one to think of the focus of her research as narrow. In fact what she was pursuing was nothing less than an understanding of the entire organism. The word 'understanding' and the particular meaning which she attributed to it is the cornerstone of Barbara McClintock's entire approach to science. For her the smallest detail provided the key to the larger whole. It was her conviction that the closer her focus, the greater her attention to individual detail, to the unique characteristics of a single plant, of a single kernel, of a single chromosome, the more she could learn about the general principles by which the maize plant as a whole was organised, the better her 'feeling for the organism' (Keller, 1983, p101).

Keller holds that McClintock herself was not subject to typical feminine socialisation, and so focuses her analysis on examining why science repudiates McClintock's methods in the main (as deviant), rather than on why McClintock herself uses them (Keller, 1987a, p42). She argues that there is only one place in which McClintock's sex is important: as McClintock is not a man she does not have to prove her masculinity in science by adopting masculine methods (Keller, 1985, p174). Instead Keller argues McClintock was pursuing a gender-neutral science:

> in her adamant rejection of female stereotypes McClintock poses a challenge to any simple notion of 'feminine' science. Her pursuit of a life in which 'the matter of gender drops away' provides us instead with a glimpse of what a 'gender free' science might look like (Keller, 1983, pxvii).

Elsewhere Keller argues that some women have, however, conformed to the norms and practices of science:

> professional success [for women in science] requires conformation to norms that remain, in opposition to what the culture, even today, labels "feminine" ... the exclusion of values culturally relegated to the female domain has led to an effective "masculinisation" of science - to an unwitting alliance between scientific values and the ideals of masculinity embraced by our particular culture (Keller, 1987~~a~~b, p79-80).

McClintock does not conform to theories of feminine socialisation, and her practice of science differed from the dominant paradigm, which Keller associates with masculinity. Moreover, Keller argues that women who practice a masculine science do not conform to their prescribed gender role in society. Although Keller argues,

> actual human beings are of course never fully bound by stereotypes, and some men and some women - and some scientists - will always go beyond them. But at the same time stereotypes are never idle. To a remarkable degree, to learn to be a scientist is to learn the attributes of what our culture calls masculinity (Keller, 1992a, p47),

I would nevertheless argue that these two types of women - McClintock and women scientists practicing masculine science - defy simplistic categories and highlight the important problem of stereotypes about women or men in science.

3.4.3 Problems with the Feminist Critique of Gender Ideology in/of Science

The role of gender in science is illustrated by feminist critics in their discussion of the function of gender ideology, rhetoric and stereotypes. However this analysis is mainly at the epistemological level of science. In my view the function of such ideology in the actual practice of science is still unclear. This is in part due to the general difficulty which exists in relating epistemology and ideology to scientific practice, ie the relationship between theory and practice. Keller's is one of the few discussions of how gender ideology functions in the practice of science, ie the legitimation of good science. However she provides us with an excellent example of how this process of legitimation breaks down in the case of Barbara McClintock. Although belatedly, McClintock was nevertheless honoured in science for heretical methodology.[7] Her theory is now an important part of molecular genetics. Keller does not discuss how often this type of theory is recognised, and if it spawned other less 'masculine' theories. Similarly, McClintock (and other women in science who may have been socialised in a more traditionally 'feminine' manner) appear to contradict Keller's emphasis on the cognitive development of the scientist as an explanation of the way the "masculinisation" of science is reinforced.

This leads me to question further the role of stereotypes and ideology of gender and science. I would argue that the first problematic stereotype is of masculinity. A popular example of this comes from object-relations theory which can be accused of psychological essentialism.[8] Child development is undoubtedly one feature of socialisation experienced by each individual. However there are many other 'layers' of socialisation as a child matures into an adult. For example, masculinity is constructed in the work place (including the institutions of science) as well as in the home (see Cockburn, 1981, 1983, 1985). This complexity of gender development challenges the psychoanalytical notion of an unstable and fragile identity based on

---

[7] Note that other biologists have claimed that the interactionist parts of McClintock's theories can be eliminated, or placed in a reductionist framework. However, this may be more of a reaction against the valorisation of McClintock's feminine methods by some feminists (not Keller) than a fundamental reason for the recognition of McClintock in the first place.

[8] This argument can be adapted to criticise socialisation theory for being socially deterministic and for not taking account of the individual's capacity to reject socialised values; and for treating society as uniform. Radical/cultural feminist biological essentialism, which appeals to arguments about men's natures, can be criticised as biologically determinist. See Segal (1987) and Connell (1983, 1987) for a fuller critique of the different theories of gender in feminism.

early child development. Indeed, there are many social processes which act to reinforce masculine identity through reinforcing male power over women.

Although she recognises that stereotypes are never fully binding, Keller's argument rests on a generalisation about individual scientists' psychological development. Whilst some male scientists undoubtedly have fragile egos it is another thing to accept that this is the norm. Generalisation is a problem for all of the theories of gender, not only object-relations theory. How are we to explain people's behaviour when it does not conform to stereotypes of gender, eg women scientists who adopt orthodox (masculine) methods? And what proportion of people (scientists) do not conform? Object-relations theory does not sufficiently account for the differences *amongst* women (or men). Moreover, the generalisation about parenting practices is equally problematic. As Fee argues, 'object relations theory cannot bear the weight of explaining the larger historical structures of economic and political power' (Fee, 1986, p49) - for example, object relations theory cannot account for different family arrangements, particularly now as the nuclear family in the West is breaking down in many countries. I would therefore argue that there are many different types of masculinity, which vary across race and class. How do these differences fit into a theory about male scientists' masculinity?

Haraway (1989), in 'Biopolitics of a Multicultural Field', compares Japanese and Western primatology. This usefully draws out some of the problems with generalising about a masculine scientific method. Haraway notes that Japanese primatology takes a very different approach than its Western equivalent. Most significantly, the separation between the object and the observer is missing (p245). She notes the strong Japanese cultural preoccupation with mothering and how this is reflected in primatology. Haraway lists the following features of Japanese primatology:

> Holism, appreciation of intuitive method, presence of "matriarchal" myth systems and histories of women's cultural innovation, cultivation of emotional and cognitive connection between human and animals, absence of dualist splits

> in objects of knowledge, qualitative methods subtly integrated with rigorous long-term quantification, extensive attention to the female social organisation as the infrastructure grounding more visible male activities, and lack of culturally reinforced fear of loss of personal boundaries in loving scientific attention to the world (Haraway, 1989, p256).

However these qualities coexist with male domination in Japanese primatology, and a Japanese Buddhist philosophy of transition from lower states of animal to human, and of pollutants coming from animals, women and the body. Haraway argues that this is also a masculinist epistemology.

This raises important problems for the feminist analysis of fragile masculine egos and separation and control within science, based on object-relations theory. Japanese primatologists are raised by their mothers, yet their methodology is not compatible with a masculine ego as defined by object-relations theory. Wider and more complex social relations obviously modify peoples' behaviour fundamentally. This problematises the feminist theorists' excessive dependence on child development as an explanation for masculinist science and further generalisation about gender and society within their theories.

The myth of objective science is worth considering further. How does the myth of objectivity relate to actual scientific practice? We have already seen that the myth of objectivity maintains the privileged position of (male) scientists and scientific knowledge in the community. Similarly, appeals to objectivity within science are used as rhetorical devices to promote one approach over another.

In the past scientists and philosophers have appealed to links between masculinity and objectivity. The reasons for this are complex. The set of dichotomies between masculine and feminine that arose in the Enlightenment may have been rhetorical devices to promote the separate spheres of men and women (as Bleier, 1984 argued). Male scientists may have used this to secure support and legitimacy for their new empirical approach to understanding the natural world. Similarly the seventeenth century characterisation of nature as a wild and untamed female was certainly used as a justification for the new science, whose alliance with 'masculine' control and domination was the necessary corollary (see Merchant, 1980).

Others have suggested that masculinity and objectivity are actually linked in practice. The reason might be, for example, a deep seated male fear of women's reproductive power, and close links with nature, and a consequent need to control (Daly, 1978; Easlea, 1978, 1981). Another possible argument comes from object-relations, as advanced by Keller.

However, modern science has moved on since the time of Bacon and the link between masculinity and objectivity is now denied by most scientists and philosophers. Few openly argue that women cannot do science. Now it is feminists who are in the strange position of defending the existence of such an association in their efforts to explain the seemingly pervasive link between masculinity and science. Are the links between masculinity and science now used by feminists as rhetorical devices or do they have concrete substance?

Rhetoric of domination and control within science, whatever its extent, may be little to do with scientists' fragile masculine identities (which can be reinforced through this type of controlling science). Scientists may appeal to a rhetoric of domination and control in methodology without actually taking such a manipulative approach. This may be about language as opposed to practice. Whether this is rhetorical or practical, it may appeal to what has come to be valued in science, through tradition. Can the traditions of science be transmitted through repetition, without links to a particular psychological state of individual male scientists? For example, the way scientists are trained is a powerful mechanism for maintaining the status quo of experimental technique within science. The appeal/approach today may be little to do with the original reasoning behind this approach in the 19th Century.

In reality scientific knowledge is value-laden. But the extent to which masculine values are shaping the *content* of different types of scientific knowledge is not yet clear. Do all male scientists have masculine values? Are all male scientists transmitting their masculine values into scientific knowledge? Are these values uniform?

An important point relevant to this issue that comes from the radical science critique related to the stereotype of a homogeneous scientific community. As Rose and Rose (1976a) have shown, there is a difference between scientific *workers* and the smaller elite of *scientists*, who act as producers of ideology. This has implications for the feminist critique. The scientific workers do not have control over the means of production and therefore, presumably, little choice about the research questions they work on or the methodologies they employ. They are involved in the mundane processes of science and have little influence over the final content of scientific knowledge. This brings into question the extent to which scientists' masculinity is reflected in science, when so many have little influence. The division of labour in science adds another dimension to the feminist critique of the masculinity of science.

These issues require further investigation to develop a clearer picture of the relationship between gender, sex and science. In the next section I move on to consider more recent critiques of science which concentrate on the role of language in science, treating science as discourse.

3.4.4 Language and Metaphor

A more recent development in feminist analyses of gender and science treat science as a discourse.[9] This approach comes from Foucault, a French philosopher and historian (1926-1984), often thought of as one of the first postmodernists, although he rejected this label (see Foucault, 1973).

---

[9] See Bleier (1984) for an early approach and Keller (1990, 1992b) Martin (1989, 1991) for later more fully developed example. See Haraway (1989) for a fascinating analysis of primatology, which treats science as story-telling.

SSK has developed this approach (Gilbert & Mulkay, 1984) and has a general interest in linguistics in science (Latour and Woolgar, 1979, Knorr-Cetina, 1981). Discourse can be considered as ways of talking and writing about the world, shared by a social group. In the case of science we can think of the assumptions shared by scientists about good practice and see this reflected in the language of scientific writing. This approach shares the methodological internalism of much of SSK, and, like it, performs more of a descriptive than explanatory role. As argued earlier, this is obviously problematic for feminists seeking to understand the role of gender in science.

An extreme approach in this area reduces scientific work to a form of writing (Knorr-Cetina and Mulkay, 1983, p10, on Latour and Woolgar, 1979, 1986). Priority is placed on organisation of meaning within scientific discourse and not on action. The aim of the analyst is to improve understanding of these accounting practices. However the privileging of one analytical perspective over another became problematic. A reflexive approach was therefore adopted as discourse analysis progressed. Authorship was deconstructed and the 'new literary forms' adopted 'multivocality' and largely abstained from coherent argument.

This type of approach can be criticised for not furthering our understanding of science and leaving us where we started: with the status quo. For feminists seeking to change science this is clearly unacceptable. However the SSK treatment of scientific discourse raises one important issue for feminists, namely illustrating the need for a strong justification of a particular feminist analysis over another.

Keller provides a fascinating example of the feminist approach to discourse analysis in her article 'From Secrets of Life to Secrets of Death' (Keller, 1990, based on earlier work Keller, 1986, see also 1992b). Keller's move into discourse analysis was based on a desire to work on the relationship between science and language, as the 'next step' in understanding gender and science (see, for example, Keller, 1992b). In this article she explores the search in biological science for 'the wellspring of life and, simultaneously, for ever more effective instruments of death' in physics (Keller, 1990, p177). Keller continues to use psychoanalysis, but this time concentrates on the language employed in articulating these two aims in science. Keller juxtaposes the two stories and focuses on

> certain interweaving of fantasies of birth and death, that, at least on a psychological level, can be seen to connect the project of uncovering the secrets of life with that of producing instruments of death rather than distinguishing them (Keller, 1990, p182).

Keller goes on to consider how these stories share a particular theme of male appropriation of female procreativity (p186). She considers, for example, Mary Jacobus' paper on James Watson's account of the discovery of DNA, *The Double Helix* (Jacobus, 1982), which describes the 'symbolic displacements' of women and adds her own analysis of 'the displacement of life itself' (Keller, 1990, p187). The metaphors of bombs as babies in the development of the atomic bomb is considered by Keller as again a metaphor reflecting a 'deadening of flesh-and-blood' (ibid). Keller argues:

> Surely, the fantasies I describe can neither be seen as causal (in any primary sense) nor as inconsequential. Where then, between causal and inconsequential, are we to place the role of such fantasies? - fantasies are in one sense private, but at the same time collectively reinforced, even exploited, by collateral interests. What is their role in the dynamics of the overtly (and primarily) public and political crisis we find ourselves in? (Keller, 1990, p189).

Before considering how Keller later approaches the question she raised here I want to take a short detour to consider the approach taken by another theorist, Emily Martin (Martin, 1991).

Martin, an anthropologist, explores the way in which culture shapes how biologists represent their 'discoveries' and looks at how the 'gender stereotypes are hidden within the scientific language of biology' (1991, p486). Specifically, Martin considers representation of the egg and the sperm, and how, despite newer accounts of their relationship, the hierarchical imagery of older accounts is still evident:

> Even though each new account gives the egg a larger and more active role, taken together they bring into play another cultural stereotype: women as a dangerous and aggressive threat. In the Johns Hopkins lab's revised model the egg ends up as the female aggressor who "captures and tethers the sperm with her sticky zona", rather like a spider lying in wait in her web (Martin, 1991, p489).

Martin links this imagery to male fear of engulfment by the mother (ibid). She then goes on to argue that these metaphors affect scientific practice and wider social practice:

> The stereotypical imagery might also encourage people to imagine that what results from the interaction of egg and sperm ... is the result of deliberate "human" action at the cellular level. Whatever the intentions of the human couple, in this microscopic "culture" a cellular "bride" (or femme fatale) and a cellular "groom" (her victim) make a cellular baby ... Endowing egg and sperm with intentional action, a key aspect of personhood in our culture, lays the foundation for the point of viability being pushed back to the moment of fertilisation. This will likely lead to greater acceptance of technological developments and new forms of scrutiny and manipulation, for the benefits of those " inner persons" (Martin, 1991, p500).

Here Martin draws clear scientific and social implications from representations of eggs and sperm, and shows us how images are a product of ideas about masculinity and femininity in society. The extent to which this is related to a masculine culture of science and how this comes about is not, however, considered. For this we must go back to Keller, who picks up the story of reproductive and developmental biology.

Keller argues that metaphors of gender in science work in two ways:

> they import social expectations into our representation of nature and by so doing they simultaneously serve to reify (or naturalise) cultural beliefs and practices (Keller, 1994, p90).

Interestingly, Keller now rejects her earlier theories concerning the projection of the 'mindset' of scientists onto the natural world as,

> unduly limited - above all by its failure to take into account the particular kinds of material consequences that models or metaphors of domination have, and accordingly, the particular kinds of material ambitions such models support (Keller, 1994, p90).

She continues to argue that the problem with the feminist arguments about the use of gendered metaphor is that they,

> are often read in caricature, to approximate a kind of conspiracy theory ... [but that] metaphors clearly do not by themselves drive the production of scientific knowledge; nor is language, by itself, capable of conjuring up material effects ... but language does guide the human activities necessary to the construction of material effects (ibid).

In considering how metaphors function in relating representation and action Keller looks at two examples. The first is the role language plays in 'conceptually magnifying' (p120) our ideas about differences and similarities in, for example, the way metaphors about race and gender in the nineteenth century lead to scientific work on the similarities between African men and women (see Stepan, 1982). The second way in which language functions is in guiding the construction of new scientific instruments, for example the metaphor of the mind's eye can be related to the development of the microscope. In both these cases the resultant scientific work expanded and strengthened the original metaphors.

This insight is of crucial importance in understanding the role gendered metaphors play in shaping the direction of scientific research, both in aims and objectives, and in shaping innovations in scientific instruments. Thus Keller has gone further than other theorists towards a more practice-oriented analysis of gender and science. However, it is still difficult to provide a comprehensive picture.

Sandra Harding also takes a useful approach to metaphors in science. She stresses the mutually supportive relationship between three aspects of gender in science: individual gender, gender symbolism and structural gender (division of labour etc). She argues that this helps to clarify how metaphors shape practice:

> gender symbolism has provided resources for the moral and political advancement of scientific modes of knowledge seeking ... this is always supported by actual division of labour or threats to existing gender-divided activity (Harding, 1986, p111).

Harding introduces historical examples from the Enlightenment, drawing from Merchant (1980), to illustrate her argument about the rhetorical role of gender metaphors. These were used to,

> make morally and politically attractive the new conceptions of nature and inquiry required by experimental method and the emerging technologies of the period (Harding, 1986, p113).

She notes that gender symbolism is often in the margins of scientific texts, for example anecdotes, and functions as an appeal for approval from the audience, which is assumed to be male.[10]

3.4.5 Problems with the Feminist Critique of Gender and Scientific Discourse

I view discourse analysis as useful up to a point in analysing gender and science, but feel that scientific practice goes beyond the written, or spoken, word. Language is clearly important, but science is a highly practical activity. Maybe tactile interaction with natural objects also determines how scientists do science. The importance of tactile interaction is highlighted by the work of several scholars in SSK, who have examined the nature of skill and tacit knowledge in science (Collins, 1974; Ravetz, 1971). As well as determining future research and practice, scientific language may conceal previous practice. Scientists' anecdotes about science in popular writing

[10] An example Harding uses is from Richard Feynman, who, in a Nobel lecture, compares his feelings for ideas to falling in love with women. Young theories, which Feynman finds attractive, come from old and worn-out theories, which have become less attractive (Harding, 1986, p120).

and speeches, and in their formal research reports, conceal other aspects of their activities, as we have seen in the earlier discussion about the use of rhetorical devices in science (Section 3.4.2). Harding's contribution highlights the role language has played in legitimating particular types of scientific inquiry or gender division of labour. Gendered metaphors are used to gain approval from the male scientific audience. Another example, drawing on Keller's main concern, might be appeals to control and domination to give legitimacy to a particular approach. A further problem with the feminist discourse analysis of science reviewed so far is that the theoretical underpinnings of psychoanalysis require proper justification (see section 3.4.3). Psychoanalysis may not be the best tool for understanding social relations and discourse in science. All of these factors suggest a more complex picture of the relationship between practice and language in science.

Keller's interest in fantasy, and how this shapes scientific practice, is understandable, given the usefulness of the Lacanian type of psychoanalysis she employs for understanding fantasy. Nonetheless, the role of individual or collective fantasy in determining scientists' practice should not be over-emphasised. The relationship between fantasy and science is by no means uniform across all branches of science, nor is it even fundamental in shaping scientific research. The particular discourses feminists are analysing - weapons of mass destruction, reproduction and discovering the basic chemical building blocks for life - are all highly emotive issues, ripe for gender metaphors. What about the vast majority of science, which is much more mundane, and does not involve such visibly 'path breaking' research? Most research science is less fundamental - for example, developing new techniques to study cell pH in renal physiology. All of these factors mean that the role of fantasy in determining scientific practice must not be over emphasised.

These problems, added to those raised earlier in relation to feminist theories about objectivity and masculinity, mean that clear picture of how the practice of science is gendered is missing. I now move on the studies of androcentric (male-centred) science, as this work might help by giving examples of concrete practice in science. This illustrates the interactions between societies' and scientists' ideas about gender and sex, and their research into sex difference.

3.5 Science of Gender

There is a wide range of articles and books criticising many different aspects of scientific research, for example, ethology, primatology, endocrinology, sexology, sociobiology, medicine, psychology and physiology (see for example, Hubbard, Henifin & Fried, 1979, 1982; Hubbard & Lowe, 1979, 1983; Bleier, 1984, 1986; Birke, 1986, 1992a; Fausto-Sterling, 1985; Haraway, 1979, 1986, 1987; Tuana, 1989). Research into sex difference from a feminist perspective is of particular interest in this study of the gendering of science. Here I deal with a case study of the psychology and biology of sex difference in section 3.5.1 to illustrate the main themes in the feminist critique, before going on to discuss these more generally in section 3.5.2.

3.5.1 Case Study: Sex Difference Research

It is worth considering one example of the feminist critique of research into sex difference in detail to highlight the issues involved. 'In pursuit of difference: scientific studies of women and men' by Lynda Birke (Birke, 1992a, p81-102) gives details of the main problems with sex difference research. The first area of difficulty is the allocation of sex to a baby depending on the shape of their genitals. Birke points out that the dichotomy between male and female is not always so unambiguous, 'even the chromosomes are not as dichotomous as appears at first sight, even chromosomes cannot always indicate whether a person is male or female' (Birke, 1992a, p82). Some individuals are born with a combination of male and female genitalia. Second, as they grow up there is a significant similarity between girls and boys in the first ten years of their lives. Differences in shape and size that occur around puberty are the result of different hormone levels in men and women. However both men and women have all the sex hormones present in their bodies, the difference is that men have more of the male hormones, androgens, and women have more of the female hormones, oestrogens and progestins.

Third, Birke points out that there is no absolute physiological difference between the sexes, and that many of the sex differences in physical attributes, like height and weight, have a significant overlap. These qualities change over time, and in different communities, as they are dependent on amounts and types of exercise. The argument that males' physical dominance in sport is because of innate biological characteristics is challenged by this information.

Turning to differences in the brain, Birke highlights a fourth area of difficulty with this type of science when she argues that typical justifications for male dominance in certain intellectual pursuits is flawed. More modern theories focus on the different qualities and abilities of men's and women's brains. Birke criticises in detail studies which look at people's skills and the different parts of the brain. Much of this research is based on knowledge about how animals' brains work: for example knowledge gained via electrical or chemical investigations. Observation of people who have suffered brain damage is also utilised: for example the left hand side of the brain is known to specialise in speech. This type of 'evidence' is clearly patchy and based on assumptions about similarities between animal and brain functioning and generalisations based on the changes between pre- and post-accident brain functioning.

Researchers have inferred from psychological tests of visual and spatial abilities that males and females think differently. They then infer that this is related to brain symmetry because some of these skills are supposed to be associated with one side of the brain. Women are understood to be more 'left brained' as females apparently perform better at language, which is associated with the left hand side of the brain. In contrast, men are supposedly more 'right brained' and more 'visual'. This is sometimes used as a reason for why so few women become scientists or engineers.

I have even heard it given as a reason for men's interest in pornographic imagery, and women's interest in erotic literature. Birke argues that,

> the mass of inferences and assumptions far outweighs that of clear evidence ... tests may measure only a very limited range of appropriate skills ... It is unsure what is being measured ... there is an enormous overlap ... A second strand of criticism is that the alleged links between brain asymmetry and sex difference often contradict themselves ... we should [also] not automatically assume that any difference between men and women in performance of psychological tests is due to biology ... (Birke, 1992a, p99-100).

Birke notes how our society attaches a great amount of importance to such stories of difference. Both in popular accounts, and in supposedly 'serious' science, over-stating the case is common (Birke, 1992a, p100). This obviously acts to 'explain away' differences between men's and women's participation in science as biological and implies that nothing can be done to change the situation. Hence the status quo is perpetuated.

This work clearly illustrates the detailed way in which scientific research into sex difference is constructed. Birke makes four important points.

1. She highlights the inferences and assumptions which shape scientists research; some of which are evident in the wider culture (eg the assumption that differences between men and women is biological); and others which may be more specific to this type of science (eg that animal brains can tell scientists about human brains)
2. The cultural construction of sex, and the overlaps between men and women in many aspects of physiology is also noted by Birke.
3. She draws attention to the contradictory nature of much of the research.
4. The role sex difference research plays in legitimating the status quo is also noted.

This has parallels in the radical science movement's treatment of ideology of/in science. The theme of good science/bad science also has parallels in Birke's treatment of sex difference research, when she criticises science at an empirical level, for bad methodology, raising the possibility that the research could be more empirically accurate, and therefore better.

3.5.2 Androcentrism in Science

Section 3.5.1 illustrates several key themes in the feminist analyses of how scientists' understanding of sex is a product of patriarchal culture and how their research serves to perpetuate the status quo. I will now consider these in more detail.

Looking first at scientific research into sex differences, several authors argue that scientists' understanding of what is male and what is female is related to the 'power of naming' (eg. Hubbard et al, 1982). For example:

> Having designated the disease of "femininity" we can easily prove its existence by innumerable symptoms of "feminine" behaviour which females display to be worthy of their given name. When men display similar behaviour the bimodal model is preserved by saying that they, too, can occasionally be "feminine" (persistence, however, indicates "abnormality") (Hubbard et al, 1982, p3).

People, in fact, vary a great deal and examples can be found to prove any bimodal distribution, for example, that fat people are cheery. The issue of proof is important: there may be other reasons that people who are overweight appear cheery. This is similar to the point raised by Rose in his critique of the science of IQ (see section 3.2). The matching of black people with lower IQs did not mean that black people were less intelligent. Their social circumstances and unfamiliarity with the questions used to measure their 'intelligence' may have been other important contributory factors. The overlap between, for example, fat people who aren't cheery and thin people who are, is the grey area in between, where the exceptions to the rule are placed. However, the fact that this 'grey area' is reasonably large, and would be a similar size with a different hypothesis, is not typically addressed in orthodox research into sex or race difference.

Hubbard argues that what is important is who has the power to choose names: 'the limits of our language presents the limits of reality as we know it' (Hubbard et al, 1982, p4). She takes the view that language restricts us to think in terms of opposites: male and female; black and white; fat and thin. These dichotomies shape scientists' understanding of the world, and the classification system they adopt. As we saw when considering underdetermination of scientific theories and theory-ladenness of observation, scientists tend to find what they are looking for.

The scientific quest for innate biological femininity is, in fact, misguided, according to feminist critics, as women and men are primarily social beings,

> from the moment of birth each of us is admitted into a social club whose membership, at least until the advent of transsexual surgery, has been considered fixed for life. The rules of this membership are often the most stringent that will ever be invoked to govern our conduct (Hubbard et al, 1982, p9).

In other words,

> what we must begin to give voice to as scientists and feminists is that there is no such thing as a place underneath it all ... the only accurate locus of research about us ... is the changing, moving complex web of our interactions, in light of the language, power structures, natural environments ... and beliefs that weave it in time (Hubbard et al, 1982, p9, quoting Star, 1979).

We must now ask why scientists bother to try and find an 'underneath' and to separate nature and nurture?

Feminist critics argue that scientists ask questions about sex difference in order to perpetuate the status quo. The idea that behaviour is determined by nature, and not nurture, is used to suppress women, by limiting them to their 'natural' role. As Steven Rose argued in the radical science literature, biological reductionism is profoundly ideological (see section 3.2). Hubbard et al (1982, p284) explore sociobiology, arguing that it is a backlash against feminism and has been used to justify discriminatory practices in employment. Bleier argues that the intense media interest and popularising of the theories indicates that the question of innate sex difference is of immense social, political and economic consequence (Bleier, 1984, p3). It is interesting to consider how these theories of 'women's nature' have a built-in flexibility and so are able to rationalise different women's positions dependent on class and race:

> A generalised description of woman's biological nature has been created, but when it comes to explaining the status of actual women the picture, as we would expect, is modified. The arguments used to explain and rationalise the position of middle class white women and working class black women in the nineteenth century are necessarily somewhat different. However, they all somehow involve the capacity to bear children. The universal, idealised description of the nature of women that has been constructed from this multiplicity of pictures tends to correspond quite closely to the myth of the nature of women as passive, nurturing, and focusing on motherhood and domesticity (Hubbard & Lowe, 1983, pxi).

Theories of women's nature act in the service of racist as well as sexist ideology.

Scientists are, in effect, involved in perpetuating social inequality:

> commitment to a gender ideology and to gender difference in scientific research has great force and implacability for several reasons. It is a scientific commitment identical with a personal, individual commitment of some scientists and a collective social ideological commitment; that is, it has great public sanction as a subject of investigation that *everyone* understands and most find comfort in ... that is a commitment to the gender status quo in society at large and within university departments and laboratories in particular (Bleier, 1986, p10).

This does not involve any conspiracy amongst scientists in a simplistic sense; but, according to Bleier, it does protect the position of men in science. Moreover, there is a definite link between subjective beliefs and experiences amongst some individual scientist and the theories that they produce (ibid, p11).

To summarise, the main issues identified by feminists in this area are as follows. First, the 'power of naming', and second, how this cultural construction of dichotomies between men and women shapes experimental design and ultimately the results of research. Third, the problem with uncovering an innate biological difference between men and women when the evidence in so murky, and fourth, the way in which these types of theories perpetuate the status quo. These are important pointers to understanding ways in which science is linked with gender in practice.

3.5.3 Problems with the Feminist Critique of the Science of Gender

There are several problems with the feminist analysis of the science of gender. First, as I argued earlier in section 3.4.3, the emphasis on language in the feminist critique of science is important, but how deterministic is it? People do think in terms of dichotomies based on their socialisation, of which language is a part. However socialisation is never simple, and subversion of traditional beliefs about male and female is possible, and this in turn can change language, as feminists have done. Language is an important part of socialisation, but its significance in shaping societies' values should not be exaggerated. Values also shape language.

Second, sex-difference research is a relatively small area of science. How do all the other biological sciences, as well as the physical sciences, perpetuate the gender status quo? And, is all sex-difference research aimed at social control? Birke does us an important service by uncovering the rampant sexism of some of the sex-difference research that is going on. But is it all so outrageous?

Third, to argue for no 'nature' within scientific understanding is problematic, as Birke herself notes:

> There are undoubtedly powerful social divisions in our society; and feminists must insist that these are not caused by the biological attributes (sex or colour of one's skin, for example) with which they are sometimes associated. But at the same time, feminists must also insist that we experience those divisions as embodied persons. Refusing to see our biology as primary and controlling is essential: human behaviour and social organisation are not caused by biology *or* by the social/cultural environment, and we are puppets of neither. But we do have bodies. (Birke, 1992b, p77).

This raises a fourth point the problem of criticising scientific research - feminists criticise 'bad' science as it is riddled with dodgy inferences. Does this mean that some science is less underdetermined than other science, or is it all equally contingent? Against what criteria are we to judge claims in science?

3.6 Women Scientists' Response

How do women in science react to the feminist critique of science as masculine? In this section I investigate their views.

Many women scientists are hostile to claims that science is masculine. Keller has written about how women in science respond to the feminist critique of science as masculine, based on her experiences as a woman in science and a feminist critic of science who has spoken with a lot of women scientists (see Keller, 1982, 1987c). She argues that their hostility is a product of their struggle to gain acceptance in science: for many women this has depended on the disavowal of any difference in how men and women do science. Moreover, following their scientific training, women scientists tend not to think of gender and sex as separate. This means that issues around gender and science reduces to the question of whether men and women think differently, a suggestion that is rejected by women in science because it is seen as threatening to their position (Keller, 1987b, p43).

Women scientists tend to reject any congruence with objectivity and masculinity because of its associations with statements that women are not suited for scientific careers (Keller, 1987b, p40). They also share with men a vested interest in their authority as scientists (albeit limited because they are women) and are likely to reject the notion that objectivity is a myth. Scientific training remains largely in isolation from any sociological study of science. As Anne Fausto-Sterling, a feminist critic of science and practicing scientist, notes, science students tend not to take social science courses, which leaves them largely oblivious to the social shaping of the scientific enterprise (Fausto-Sterling, 1992). Harding, a philosopher who has spoken with women in science, in a comment on Fausto-Sterling's piece adds,

> it is no accident that scientists turn away from both learning more about the social context of their own work, or modern Western science more generally, and from exhibiting what little they learn to innocent young folks whom they wish to recruit to careers in their field (Harding, 1993, p50).

A disdain amongst scientists for sociological understandings of their own work and disciplines is evident (ibid).

Finally women scientists may find the feminist critique problematic, because they interpret the suggestion that science is socially shaped as meaning that all scientific knowledge is equally valid. Although this is a misreading because few feminists take such a relativist position, it is understandable, given women scientists' unfamiliarity with the difficult language of the feminist critique and their beliefs in the value of rigorous empirical investigation.

This interpretation of how women scientists come to be so hostile to the feminist critique of science as masculine fits into the feminist theories of gender in scientific practice sketched above quite well. The main issue seems to be the epistemic authority gained from the myth of objectivity for both women and men in science. The reliance on this myth is, ironically, perhaps more important for women in science than men, because of their need to assert legitimacy which is so limited in other ways.

However, this type of argument, highlights problems in the feminist critique. The argument that women in science are socialised to reject the masculinity of science can be construed as a suggestion of false consciousness. This is patronising to women in science and will alienate them even more. Furthermore, as we have already seen, socialisation arguments (in this case of women scientists who are hostile to the feminist critique) are problematic because they fail to account for those who do not fit into the stereotype. The authority to be gained from science is obviously one aspect of many women's hostility, but there are other factors.

An important issue is the relevance of the critique, based mainly on human and animal biology, to other women in science, eg women in physics. The lack of congruence to their own experience or subject matter will contribute to women's dismissal. Another point which might explain women scientists' hostility, is the level at which much of the critique is conducted, involving sociological and philosophical concepts. These women are practicing scientists and much of the discussion may not relate to their experience of how science gets done, or their experience of men within science. Whilst their view is obviously limited by the institutionalised lack of self-reflection amongst scientists, they do have a point. There may be aspects of their practice that feminists are glossing over in their concern with language and rhetoric. For example, returning to the point about the difference between scientific workers and scientists, many women in science fall into the former category. This again limits the type of science they practice to replication of other work and means that few have the opportunity to develop new research let alone head a research team. This may well limit their perspective on how science is linked to gender ideology.

Moreover, women scientists' rejection of an extreme relativist position is important. The feminist critique of science has yet to resolve the conflict between social constructivism and good science/bad science, or to clearly establish the criteria for judging valid knowledge claims. In a sense this leaves a vacuum which promotes women scientists' rejection of the feminist analysis of science. A total rejection of empiricism may not be in the best interests of feminists seeking to adjudicate between knowledge claims. Surely feminists are seeking a 'better' account of the natural world. It is also quite arrogant to assume that nature has no part to play in the construction of scientific knowledge, and that humans construct the whole picture. Haraway makes this point:

> Just how science "gets at" the world remains far from resolved. What does seem resolved, however, is that science grows from and enables concrete ways of life, including particular constructions of love, knowledge and power. That is the core of its instrumentalism and the limits of its universalism (Haraway, 1989, p7-8).

She argues that primatologists must listen to the animals, who are active participants in primatology. This can be compared with Keller's account of McClintock's emphasis on 'listening to the material' (Keller, 1983), and will be discussed further in the next chapter about a feminist science.

3.7 Conclusion

The feminist critique of the gendering of science presented here has brought gender into the social analysis of science. Feminists have argued that science is not objective, and that the interests and views of scientists are reflected in the science they produce. Given that science is male-dominated these views must, to some extent, reflect male values. Objectivity has been linked to masculinity in the feminist critique. Feminists have documented the links in liberal philosophy between masculinity and the values of science: objectivity and reason. Others have argued that this link is more than rhetorical, but is reflected in the fragile male ego developed through mother-child relations. Language and metaphors in science have been analysed by feminists and show links to male fantasy (again shaped by early child development). The language of science has been shown to shape scientific practice. The final area of feminist concern with science is the science of gender. Feminists have criticised scientific research, especially that concerned with sex or sex difference, emphasising, amongst other things, the power of naming difference between men and women in shaping scientific analysis. They have illustrated the ideological role science plays in perpetuating the status quo, ie gendered division of labour. The problematic inferences and assumptions in scientific research are also criticised for producing 'bad science'.

I have shown several key flaws in these analyses. The first is the understanding of masculinity. Generalisations about a male 'world view' or masculinity are problematic for feminists. If masculinity is a product of social relations, and not purely biology, it is shaped by many different social relations which vary across ethnic groups and class. Masculinity is dynamic, not static, meaning that it develops as men grow up. The way in which masculinity is reinforced by social relations which emphasise male power over women is important. This raises problems for feminists seeking to generalise about a male 'world view' being reflected in science, or about a particular set of masculine methods.

The use of psychoanalysis in this area raises particular problems. Feminist psychoanalysis can be criticised as placing too much importance on early child development in shaping gender. Whilst this is important, socialisation does not stop at this point, but continues throughout life, as argued above. The emphasis on the fragility of the masculine ego is particularly problematic, given the way in which society acts to reinforce the male ego. Control and domination within science are linked with the fragility of the male ego by feminists. When this fragility is questioned the link breaks down. The psychoanalytical interpretation may not be the best way for understanding the gendering of science.

A further problem for feminists is their current emphasis on links between language and gender within science. I would argue that they risk falling into the same determinist trap as above, by over-emphasising the role of fantasy (again based on child development). Language clearly guides social practices, scientific experimentation and theories. However language is only one part of scientific investigation: physically doing science is important.

Moreover, language can be a rhetorical device. This is important in feminists' discussion of discourse and method. Scientists use gendered metaphors, and make connections between gender and particular practices within science, in order to gain legitimacy for a particular approach (either within or out with science). This allows for the possibility that language obscures practices which do not fit in with the dominant rhetoric, and guides further practice to conform to the dominant rhetoric. Perhaps the issue of whether scientists have a subconscious affinity with a particular approach is not as important as the way that they construct affinities (which can change) for political goals.

A third flaw in the feminist theories about how science is masculine is an inadequate understanding of how science is practiced. Hierarchies within science obviously limit the extent to which all scientists can influence their work. There is a difference between new 'ground breaking' research and the mundane repetitive work in which most scientific workers are engaged. The opportunity to construct new metaphors or theories is limited in most scientific work. Moreover, there are many different subjects within science which have different methodologies and theories. The difference between animal and human biology and physical sciences are important. Gender is obviously more important in sex difference research than in the physical science, whose role in perpetuating gender inequality is difficult to analyse.

All of these flaws can be related to women scientists' alienation from the feminist critique of science, and the important criticisms raised about criteria for judging scientific knowledge claims. The feminist (and SSK) emphasis on the social construction of scientific knowledge conflicts with the prevailing ideology which is that science is a neutral reflection, or a direct reading, of the natural world. However, as I argued in relation to SSK, it is possible to go too far in the constructivist analysis - the emphasis on methodological relativism may lead to judgmental relativism. The debate within the radical science movement about good science/bad science and use and abuse of science also highlights (mainly scientists') fears of relativism. Feminists are now faced with the same dilemma.

There is a trend in feminism today away from understanding based on women's exploration of their own oppression to abstract academic theorising. This is evident in feminist theories of science. The progressive shift towards language and metaphors is symptomatic of the trend. These theories are alien to many women scientists, and women in general. The theory has become divorced from scientific practice in many ways.

One particularly important issue relating to the gulf that has developed between theory and practice is that between theory and activism. These feminist theories can be criticised as moving away from strategic theorising (Connell, 1983, 1987) - to bring about change - to theorising for its own sake. Paradoxically this acts to reduce the possibility of change. One example of this comes from the feminist emphasis on language in science. The political move in this case would be to try to change language. However the existing feminist theories tend towards a deterministic analysis of language and masculinity. The rhetorical role of language is down-played in favour of an analysis which emphasises the role of language in determining social practices. From this perspective, in order to change language within science, and hence change science, feminists must look outside of science to parenting structures, to alter child development patterns, and so alter gender relations which will in turn change language. In my view this is not a very effective strategy for change. The psychic essentialism of this type of feminist theorising does not contribute to good strategies for political action. By contrast, arguing for links between masculinity and science in language, as rhetorical devices, may provide the basis for more realistic political action: exposure of the rhetoric.

In the next chapter I consider feminist science theories, including the position of some of the theorists considered in this chapter. I am once more interested in how the feminist science theories relate to practice, in two broad senses: the actual practice of science; and practice in terms of feminist activism around changing science.

Chapter 4 Feminist Science

4.1 Introduction

Developing a theory of feminist science is clearly an important part of the feminist treatment of science. There is undoubtedly a danger, recognised by many feminists who practice and criticise science, in failing to provide an alternative to the current gendered science. Science is too important to be dismissed by feminists. Yet it is feminists outside of science, primarily in the discipline of philosophy, and to a lesser extent the social sciences, who have since taken up the feminist science project. Theirs' is a theoretical treatment of the concept of a feminist science, and leaves many unanswered questions about the practical implications of their work. It is thinking about the nature of a feminist science in practice which guides my review of the feminist epistemologies of science.

I start in section 4.2 with a consideration of the feminist science critics' approach to the idea of a feminist science This follows on from Chapter 3 and introduces the key issues concerning the practice of a feminist science. It is these issues which I consider in the more detailed review of the three principal bodies of work in feminist epistemology of science: the theory of feminist standpoint applied to science; postmodernist additions to standpoint theory; and feminist empiricism. Section 4.3 deals with the feminist standpoint theorists (as labelled by Sandra Harding, 1986, 1991), namely Hilary Rose (1983 and 1994) and Nancy Hartsock (1983, 1984). These theorists draw from Marxist philosophy of historical materialism and incorporate a consideration of the patriarchal division of labour, involving reproduction as well as production. In section 4.4 I consider the work of Sandra Harding (1986, 1991) and Donna Haraway (1985, 1986, 1987, 1988, 1989, 1991) who develop the standpoint position along postmodernist lines, and argue instead for 'strong objectivity' (Harding, 1991) and 'situated knowledge' (Haraway, 1988). I then consider feminist empiricism in section 4.5.[11] I take the term from Nelson (1990), who develops the work of the philosopher Quine to advocate a form of empiricism which does not deny the subjectivity of the knower. I also address Helen Longino's work under this heading (1983, 1988, 1989, 1990).

4.2 From the Feminist Critique of Science to a Feminist Science

4.2.1 Feminist Critics' Views on a Feminist Science

Feminist critics of science were the first to respond to the idea of a feminist science, both negatively and positively. In many ways their responses are cautious, perhaps because of their awareness of the difficulty in theorising a feminist science when the understanding of how science is masculine is so limited. Nonetheless, the feminist critics develop their ideas in such a way as to raise four important issues concerning the practice of a feminist science. Note that although these themes are inter-related, I deal with them separately for simplicity.

First, an interesting feature of the views held on a feminist science by most feminists who are scientists and critics of science is their rejection of a feminine science, as suggested by radical feminism, cultural feminism and/or ecofeminism.[12] The tendency for feminist scientists to reject the notion of a feminine science might be related to the strong anti-essentialist element of the feminist critique of science, in particular of sex difference research in biology and psychology. An essentialist view of men's and women's 'natures' is seen by most feminist critics of science as over-simplistic and as too close to the sexist theories of difference which they are trying to

---

[11] It is important to note that I do not use the term in the same sense as Sandra Harding, who uses it to denote a liberal feminist position. This does not question the objectivity of science, but advocates a more rigorous form of objectivity as well as the entry of women into science to 'police' sexist bias (Harding, 1986).

[12] For a review of ecofeminism see Zimmerman (1987); Kheel (1985); Warren (1987); Cox (1992); Gray (1981); Fox (1989); Griffin (1984); Caldecott and Leland (1983). Another theory of a feminine science is proposed by Shepherd (1993). I choose not to review these here as I start from a position which rejects essentialism.

eliminate. In rejecting this view and drawing a distinction between gender and sex, these feminist critics imply that both men and women would, in principle, be able to do a feminist science. This raises important questions about who would do a feminist science and how they would become 'feminist scientists'. This question is explored in my review of each of the three feminist epistemologies of science. It is particularly important in my treatment of standpoint theories in section 4.3, where the issue of essentialism is paramount.

The second important concern emerging from the initial exploration of a feminist science by these critics is methodology. The nature of objectivity is particularly important. Here I explore four approaches taken to the question of methodology.

The first is developed from the feminist critique of sex difference research (reviewed in section 3.5). Importance in placed on changing science from the inside, using science's own tools to refute false claims, and to promoting women into positions of power in science (eg Fausto-Sterling, 1985). Some of the epistemological ground-rules in orthodox science are also challenged - for example the idea of a 'biological substratum' underneath the social which can be 'revealed' by scientific investigation (Star, 1979); the ideological role of science in promoting the status quo (Hubbard et al, 1982, p11); and the relationship between 'man' and nature. Environmental destruction and the treatment of animals is of particular concern to these critics of science (Hubbard et al, 1982, p287).

Fausto-Sterling, for example, argues for rigorous methodology, including proper controls, observational techniques which limit individual bias, and thorough statistical analysis. She criticises biological determinism in the science of gender from the perspective of this methodology, and argues for the development of new models of gender based on complexity and interaction which would be part of a feminist science (Fausto-Sterling, 1985, p212). However, the later approach is limited to human biology.

The implication in this work is that it is possible to distinguish good science from bad; and that the empirical techniques used in science at present can be utilised by feminists to achieve this aim. What is viewed as the 'over use' of reductionist research design and methods is rejected in favour of a more holistic approach. These critics also start to challenge the notion of objectivity in science, arguing that nature cannot be 'revealed' as distinct from the social world, but that the two are entwined. The task of science is to move towards a better understanding of nature, but the 'truth' can never be fully 'uncovered' as knowing is a social process. In addition, the ideological role of scientific knowledge in perpetuating gender inequality in the wider society is recognised and rejected. 'Good science' might take a similar role in promoting non-sexist ideology - an important aspect of feminist politics - or the ideological role of science might be rejected by feminists in favour of a more knowledgeable and skeptical public. This is also a highly practical agenda for change. The implication is that feminists could change mainstream science by becoming involved and practicing science as feminists. Presumably institutional changes would also be necessary to get more feminists into science, although this is not discussed explicitly.

Despite this practical slant to Fausto-Sterling's work, for many she does not go far enough in her critique of science. Her adoption of orthodox principles of objectivity has been criticised - it may be that 'one cannot use the master's tools to tear down the master's house' (Audre Lorde). This introduces one of the principal dilemmas for feminists seeking to change science: to what extent should old methodologies and styles be retained?

A second approach is that of Ruth Bleier, who has gone further than Fausto-Sterling and developed some suggestions for what a feminist science might be, based on 'change, complexity, contextualising, and interaction' (Bleier, 1984, p200). For example, she favours,

> restor[ing] missing subjects and points of view ... make[ing] science better and capable of a more complete appreciation of the world ... transform[ing] ideological bases throughout Western civilisation and for women's place in it (Bleier, 1984, p201).

She emphasises 'critical self reflection' and understanding of change, complexity and context (Bleier, 1984, p205). Some principles that might characterise a feminist science for her include the principle that scientists acknowledge they have beliefs that affect their practice of science; and the principle that scientists should then explore and try to understand how subjectivities affect science. Moreover, scientists ought to be

> explicit about assumptions, honest, thoughtful and careful in their methods; open in their interpretations of each study and its significance; clear in describing the possible pitfalls of the work and their conclusions about it, and responsible in the language used to convey their results to the scientific and non scientific public (Bleier, 1986, p15-16).

Following this, in Bleier's vision, feminists could claim a feminist approach to science and research that leads to oppression and exploitation would be eliminated. Scientists would recognise the true complexity of nature, and be non-reductionist (Bleier, 1986).

In my opinion this is a more idealistic vision of change than Fausto-Sterling's. Although Bleier deals more explicitly with the scientist's interaction with the natural world - emphasising critical self reflection and exploration of subjectivities - there is insufficient consideration of the relationship between changes in science and changes in society, or of the institutional changes required to sustain a different methodology in science. The processes by which more emphasis on subjectivity in science would interact with the 'myth of objectivity' in the wider society are not considered. How would scientists learn to be more self reflexive? These important questions will be explored further in my review of the feminist epistemologies of science.

The third approach, represented by the work of Elizabeth Fee, avoids the utopian problems of Bleier's alternative vision and the difficulty with Fausto-Sterling's acceptance of orthodox methods. Fee focuses on the concept of objectivity (Fee, 1983). She argues that it is 'sufficiently vague to carry with it a multitude of meanings' (Fee, 1983, p17). Positive meanings include the:

> constant process of practical interaction with nature; willingness to consider all assumptions and methods as open to question ... idea of individual creativity subjected to the constraints of community validation through a series of recognised procedures (Fee, 1983, p16).

Fee rejects what she calls the 'hierarchy of distances' in objectivity, which is manifest in four ways: the treatment of the production of knowledge as separate from its social use; the separation between scientific rationality and emotion in the language of science,[13] which she argues is a 'pervasive and powerful aspect of the mythology of science' as scientists are often deeply committed to their work (Fee, 1983, p18);[14] the distance between the subject of study and the object of study, which legitimates the domination of nature; and the view of science as separate and distinct from society.[15] Her main point is that all of these aspects of objectivity are false, and that science is political and emotional, and not separate from nature.

The strength of Fee's approach is that it is based on a serious consideration of what objectivity means in practice. This allows her to reach a compromise, between a total rejection or acceptance of objectivity. She incorporates orthodox methods of validation by peer review alongside emphasis on the effect of social context on how knowledge is developed. A feminist science, according to Fee, is therefore one which involves gradual change from existing practice as opposed to a sudden leap to entirely

[13] This issues relate to Fee's earlier critique of the liberal philosophy of science, where she illustrated the dualisms between masculine and feminine: the association between masculinity and scientific rationality on the one hand, and emotion and femininity on the other. Fee also argued that each side of the dichotomy was necessary to sustain the other, although the 'masculine' was always privileged (see section 3.4.1).

[14] This supports my point about the possibility that scientists' rhetoric of domination and separation might be distinct from their experience of such separation (see section 3.4.2).

[15] This is an important theme in the radical science movement's critique of the neutrality of science and the emphasis in SSK on the social construction of scientific knowledge (see sections 3.2 and 3.3).

new methods. This raises an important question: is it possible to compromise between orthodoxy and radically different methods? This is explored in more detail in the main part of this chapter.

The fourth and final contribution on methodology is Keller's 'gender-neutral science', which she proposed in her early work (Keller, 1985). She aims for the:

> reclamation from within science, of science as a human instead of a masculine project and the renunciation of the division of emotional and intellectual labour that maintains science as a male preserve ... [and has a] vision of a gender-free science ... premised on a transformation of the very categories of male and female, and correspondingly of mind and nature (Keller, 1985, p178).

Keller maintains that at present science involves a plurality of different theories, but that those mirroring a rhetoric of control and domination are privileged. She goes on to argue against this constraint:

> a healthy science is one that allows for the productive survival of diverse conceptions of mind and nature (Keller, 1985, p178).

However Keller contradicts this emphasis on diversity when she favours a particular methodology which she refers to as 'dynamic objectivity' (see section 3.4), which she argues is better suited to dealing with the complexity of nature than constrained 'master molecule' interpretations (Keller, 1985, p136). Here Keller introduces an important dilemma for feminist scientists: should diversity or one particular type of objectivity, eg dynamic objectivity, be encouraged? In the first case it seems that Keller is looking to mainstream science to provide the resources for change; in the second, which Keller links with feminine gender identity, it appears that change would have to come from outside of science.

This leads on to the third area of concern raised by feminist critics' initial investigation of a feminist science: the organisation of science. By organisation I am referring to the social arrangements within science, in particular: boundaries between natural science and the rest of academia, and between different scientific disciplines; the organisation of formal employment hierarchies, informal hierarchies and communication networks; organisation of the working environment; and the arrangements made to train scientists, including recruitment procedures.

Although this is not discussed by feminist critics in detail two important issues are addressed in part by Fee and Keller. Fee's consideration of objectivity leads her to suggest that a better understanding of the production of scientific knowledge is necessary in promoting a feminist science:

> we need both macro and micro studies of social organisation and its relation to knowledge production ... [it is] necessary to explore the role that scientists are given in the reproduction of economic and political power within the context of class structured society in order to understand how these relationships of power lead to the production of particular kinds of knowledge and to see why certain questions are asked and others rendered invisible (Fee, 1983, p11).

In my view Fee is arguing for a more robust sociology of science which, could then begin to shape the scientific project.[16] This might mean sociologists of science working in closer collaboration with scientists, or scientists developing sociological skills as part of their training. This type of organisational change will be discussed in more detail throughout this chapter.

The second organisational issue introduced by a feminist critic of science - Keller - concerns the very meaning of a feminist science. Keller rejects the label 'feminist science' for her ideas detailed above. Instead, she argues that the concept of a feminist science is extremely problematic, because of the popular equation of feminist and feminine science (Keller, 1987a). Keller argues that this embodies all the conflicts surrounding sex and gender, culture and nature, conflicts which she aims to overcome. In particular, she views the widespread collapse in the public mind of the

---

[16] Interestingly, this is also implied in the radical science movements' work on ideology, and in the sociology of science, although neither of these groups have met the challenge. In the former case this is largely because of internal disagreements, however in the latter the shift towards 'methodological internalism' in SSK appears to be an important causal factor.

concepts of feminist and feminine, sex and gender, as meaning that women scientists are mainly hostile to feminist criticisms of science, as they see it as meaning that women and men do science differently. Rather, she favours a more substantive critique of science which, crucially, 'depends on a rapprochement between feminist critics of science and working scientists' (Keller, 1987b, p89), a rapprochement which might well involve changes in the disciplinary boundaries between natural and social science.

Keller's rejection of a feminist science on the grounds that it is most often equated with a feminine science seems to contradict her own favouring of feminine gender traits in dynamic objectivity. Nevertheless, she does raise an important point. How can feminists convince and organise women in science? More generally, how would a feminist science be organised? Would it involve a slow change, modifying and adapting existing practices, or would it be more revolutionary, in Harding's terms, a 'successor science'? Would parenting practices have to change? These are important questions which I hope to answer.

The fourth and final issue which is raised by feminist critics of science who are concerned with a feminist science is the relationship between change to a feminist science and changes in the wider society. Once more it is Fee who raises two key points. First, she argues:

> scientific experts are in the male role whilst the vast majority of the population is given the female role. Everyone lacking scientific credentials is made to feel uninformed, unintelligent (Fee, 1983, p19).

This suggests that a feminist science should seek to involve the public to make them more informed. How might this be done? Second, Fee argues that a feminist science is not possible without a feminist society (Fee, 1983, p20). This begs the question of what is the link between feminising science and feminising society?

4.2.2 Crucial Issues for a Feminist Science

There are four sets of questions which have emerged from this review:

1. What are the necessary 'qualifications' of feminist scientists (including sex)?
2. What constitutes a feminist methodology? To what extent should feminists retain orthodox methods or introduce more radical approaches? Are there many feminist methodologies or only one?
3. How would a feminist science be organised? In particular, what would the links be between sociology of science and a feminist science?; how would scientists be trained?; and how might feminists convince scientists, especially women, to adopt their approach?
4. What would be the relationship between feminist changes in science and changes in the wider society? How would the public be involved, and does a feminist science require a feminist society?

Note that these themes are inter-related. For example, questions about methodological changes cannot be asked in isolation from questions about organisational changes needed to instigate such methods. I now address these four themes, and the ways in which they are related, in my review of the three principal feminist epistemologies of science, starting with feminist standpoint theory.

4.3 Feminist Standpoint Science

4.3.1 Introduction

The first major area of feminist theorising about science developed in the early 1980s and concerned a feminist standpoint. This is based on the notion of a proletarian standpoint.[17] Hartsock argues that the proletarian standpoint can be appropriated by feminists when considering gendered society and the two sex-classes:

[17] From a Marxist perspective standpoint theory depends on the notion of two classes: the proletariat and the bourgeois; who have different perspectives resulting from their

> the position of women is structurally different from that of men, and ... the lived realities of women's lives are profoundly different from those of men (Hartsock, 1983, p284).

Although Hilary Rose does not use standpoint theory to justify her approach in her initial paper (Rose, 1983) she does adopt the label in her later book (Rose, 1994). Rose develops her approach from the critique of the radical science movement (see Chapter 3). While acknowledging the usefulness of many aspects of the radical science theories, she criticises them for being theoretically 'sex-blind' (Rose, 1983, p81). Her main thesis is that,

> their analysis of the division of labour stops short at the distinction between the manual and mental labour associated with production. Indifferent to the second system of production - reproduction - the analysis excludes the relationship of science to patriarchy, to the sexual division of labour in which caring work is primarily allocated to women in both paid and unpaid work (Rose, 1983, p73).

Rose aims to transcend what she sees as a division between 'hand, brain and heart' (Rose, 1983, p73) in order to produce a more humane science. This involves moving on from the radical science movement's 'one-sided materialism' (Rose, 1983, p76) and developing a feminist theoretical framework which 'makes it possible to explain why science is not only bourgeois but male' (Rose, 1983, p81), ie one which explores the links between capitalism, patriarchy and science.

4.3.2 Feminist Standpoint in Science

I now consider how Hartsock and Rose construct their versions of a feminist standpoint, before moving on to consider what this might mean in practice. Both Hartsock and Rose argue that, in Hartsock's words, women's lives provide a:

---

material circumstances. On the one hand, the proletarian standpoint is the vision of the oppressed, and so renders the real relations of society visible. On the other hand, the bourgeiosies' vision, which dominates the society, is corrupted by their position of power.

> a vantage point that can be ground in a powerful critique of the phallocratic institutions and ideology which constitute the capitalist form of patriarchy (Hartsock, 1983, p288).

There are eight main points to Hartsock's argument, three of which Rose shares. First, Hartsock uses,

> the term "feminist" rather than "female" ... to indicate both the achieved character of a standpoint and that a standpoint by definition carries a liberatory potential (Hartsock, 1983, p289).

Second, she argues women's labour differs systematically from men's in every society and the sexual division of labour is the first and in some societies the only division of labour. Hartsock stresses that she is looking at institutionalised social practices, not individuals' visions, and claims that,

> individuals may change their activities in ways which move them outside the outlook embodied in these institutions, but such a move can be significant only when it occurs at the level of society as a whole (Hartsock, 1983, p289).

Third, under capitalism women produce goods for wages, but their lives are institutionally defined by their production in the home. This involves what Hartsock calls 'a unification of mind and body for the purposes of transforming natural substances into socially defined goods' (Hartsock, 1983, p292). For a woman,

> the process of production ... consume[s] [her] whole life ... Her immersion in the world of use - in concrete, many qualitied, changing material processes' (ibid).

This means that women's vantage point is an intensified version of 'the materialist world view' that Marx refers to - 'an intensification of class consciousness' (ibid).

Rose also argues that women's work is of a particular kind, and produces a particular knowledge: it is work concerned with personal service, 'emotionally demanding labour (which) requires that women give something of themselves to the child, to the man' (Rose, 1983, p83). This she calls 'the labour of love' (ibid). This can be considered a unity of 'hand, brain and heart':

> a theoretical recognition of caring labour as critical for the production of people is necessary for any adequate materialist analysis of science and is a crucial precondition for an alternative epistemology and method that will help us construct a new science and a new technology (Rose, 1983, p83).

Although Rose advocates incorporation of the labour of caring into theories of science, she does not advocate simply adding women in to the basic productionist argument. She calls for a recognition of the,

> dialectical relationship between both systems of production...(which) holds the explanation not only of why there are so few women in science, but also ... of why the knowledge produced by science is so abstract and impersonal (Rose, 1983, p84).

As a starting point Rose turns to the sexual division of labour, to look for explanations of how it came about and for connections between women's paid and unpaid work. She notes that the ideology and practice of the 'family wage' to the male breadwinner plays a central part in women's enforced dependence on men and remains today with a 'powerful ideological grip' (Rose, 1983, p85). Rose then argues that,

> science and technology as labour markets follow precisely the pattern of this general segregated form ... It excludes women - except those in exceptionally favourable circumstances - from occupying elite positions within the production of knowledge (Rose, 1983, p85-86).

Those women who do 'make it' in science are, according to Rose, 'cut in two' (Rose, 1983, p87); they face a contradiction between their caring labour and the abstract labour of scientific practice.

Fourth, both Rose and Hartsock incorporate a biological component to the division of labour between men and women. Hartsock argues that she is looking at the sexual rather than the gender division of labour: the division of labour between men and women is not purely social but includes a biological component. Women, not men, bear children, emphasising the 'biological, bodily component of human existence' (ibid). She incorporates into her notion of institutionalised sexual division of labour the concept of,

> motherhood as an institution rather than experience, including pregnancy and the preparation for motherhood almost all female children receive as socialisation, [which] results in the construction of female existence as centred within a complex relational nexus (Hartsock, 1983, p294).

Rose draws on similar arguments to Hartsock, in elaborating on her epistemology of hand, brain and heart. For example, she argues that women's labour includes the labour of birthing, arguing that this is admitting the body into feminist theory - 'a limited essentialism and constrained social realism' (Rose, 1994, p40). A feminist epistemology, based on 'holism and harmonious relations between women and nature' (Rose, 1994, p33), would require a movement towards a 'deeper respect of nature' within scientific research, possibly the stopping of animal experimentation (Rose, 1994, p233).

Fifth, Hartsock makes use of object-relations (see section 3.4.1) to explain how the experience of oneness lasts longer for female infants than males (see Flax, 1983; Chodorow, 1978). This is reinforced by socialisation: girls learn roles from their mothers, males from 'rules which structure the life of an absent male figure' (Hartsock, 1983, p294). Girls identify with the real, concrete world, boys with the abstract; '[m]asculinity is idealised by boys whereas femininity is concrete for girls' (ibid). Both different psychic make-ups in men and women as well as different activity are, Hartsock argues, replicated in epistemology and ontology: a contrasting feminist standpoint and abstract masculinity emerge as a result of these differences.

Sixth, Hartsock argues that, in considering the 'institutionalised sexual division of labour' (Hartsock, 1983, p290), it is best to search for commonality amongst women rather to explore differences across race and class. This she does with reluctance and comments on 'the danger of making invisible the experience of lesbians or women of colour' (ibid). Nevertheless she still argues that all women in the West experience the sexual division of labour.

Seventh, according to Hartsock, the female experience (the inverse of the male) exposes the masculine standpoint as 'both partial and fundamentally perverse'. This perversity is most dramatically represented in the 'substitution of life for death'. Violence, death and sexual fusion are linked to the masculine standpoint both theoretically and in real life, through rape and pornography. This 'perversity' is further evident in 'the argument that it is the ability to kill ... which sets humans above animals' (ibid). Superiority is ascribed to the male as the male kills. Hartsock describes how this male perversity is taken as the standard world-view and, as such, permeates the lives of women as well as men. For example,

> The organisation of motherhood as an institution in which a woman is alone with her children, the isolation of women from each other in domestic labour, the female pathology of loss of self in service to others - all mark the transformation of life into death (Hartsock, 1983, p302).

The female experience of continuity and relation with others, the natural world, and between mind and body, provides an ontological base for developing a feminist standpoint, which does not operate through the denial of the body, an attack of nature, or the death struggle between the self and others.

Finally, the achievement of a society-wide feminist standpoint requires the 'generalisation of the potentiality made available by the activity of women' through a feminist revolution, which, according to Hartsock, must involve 'institutionalising the participation of both men and women in child rearing' (Hartsock, 1983, p304). Rose argues that it is the task of a feminist epistemology of science to create 'a practice of feeling, thinking and writing that opposes the abstraction of male and bourgeois scientific thought' (Rose, 1983, p88). The subjective and objective ways of knowing the world are to be brought together in feminist theorising about science. This 'begins with and constantly returns to the subjective shared experience of oppression' (ibid). This in turn 'fuses the personal, the social and the biological' (ibid).

The examples that Rose gives are taken from feminist work to 'defend women's interests and advance feminist interpretations' (ibid) in biology and medicine. Feminist writing on menstruation, for example, 'fuse subjective and objective knowledge in order to make new knowledge' (ibid). Rose gives examples of self-examination books and self-health-care groups who are developing, 'not only prefigurative social forms of health care, but prefigurative forms of knowledge about natural sciences' (ibid). An example of this is the book *Our Bodies, Ourselves* (Boston Women Health Collective, 1969).

Rose comments that,

> in this situation a feminist biology does not attempt to be objective and external to the female biological entity; it attempts to take over biological knowledge in order to overcome women's alienation from our own bodies, our own selves (Rose, 1983, p89).

In a later book (Rose, 1994) Rose claims that this theory came from feminist practice, eg women's group's exploration of their common experience of daily life. She links this feminist epistemology with the women's ecology movement:

> the examples of third world women's environmental struggles, and first world women's campaigns over Genome and reproduction, show the capacity to ... enter the terrain of science and to construct new definitions of reality, infused with a feminist understanding of caring. Within these examples we see feminism bringing love to knowledge and power. It is love, as caring respect for both people and nature, that offers an ethic to reshape knowledge and with it society (Rose, 1994, p238).

I now go on to consider the translation of feminist standpoint theory into the practice of a feminist science.

4.3.3 Practice

Here I address the four main themes of this chapter, detailed in section 4.2.2, and ask the following questions: most importantly, is there such a thing as a feminist standpoint based on women's lives and how do scientists adopt a standpoint?; what does this mean for the methodologies of science?; how would science be organised?; and what is the link between a feminist science and the wider society?

I argue that the notion of a feminist standpoint is problematic for several reasons. The first relates to the way that Rose and Hartsock root a feminist standpoint in women's biological as well as social experiences. I agree that peoples' perspectives are shaped by their social location. A biological component to experience is also important. We are, after all, not purely social, but also biological creatures. But there are implications of using this as the basis for a feminist science. Rooting a feminist standpoint in women's experience, in particular pregnancy and childbirth, which only (some) women experience, implies that men cannot achieve a feminist standpoint, as theirs' is a different experience. This, in turn, implies that a feminist science based on a feminist standpoint is a separatist science: men cannot participate. In my view this is highly problematic, not least because if feminists turn away to pursue a separate scientific project, ~~and~~ they in effect leave untouched the male domination of orthodox science. The chances of a feminist science having any impact on society from the margins are severely limited. A more practical approach involves some continuity with existing science, including existing male scientists.

Second, the notion of a single feminist standpoint is difficult because women's experiences are different. One problem with the formula of a single feminist standpoint is that it shares a tendency with right wing and sexist imagery, to restrict the image of women to mothers and wives. In utilising the traditional stereotype of womanhood, standpoint theorists adopt what can only be a romanticised notion of women's caring role. Whilst women can be carers, they can also be insensitive and prejudiced, authoritarian and domineering. The mono-dimensional view of the caring mother and wife ignores these less savoury features of women's characters.

Furthermore, women's caring labour takes many forms - how much commonality do bourgeois women who employ women to clean and care for their children have with middle class women who stay at home in suburbia to bring up their children, or with working class women who have to go out to work for a low wage in a factory and constantly juggle child care amongst family and friends? The same question could be asked of different races of women. In some instances it may be that women and men of the same class and race may share more in common with each other, than with members of their sex in other classes or races. Surely different women's experiences are very different and cannot be subsumed under an idealised version of women's caring labour? This implies many different women's and feminist's standpoints. This does not mean that there is no commonality in women's experiences, but that experience is also shaped by other factors, including class and race.

Third, Hartsock's theory tends to demonise men's perspective (eg Hartsock, 1983, p290). Is this helpful in promoting a feminist science? The perversity of the masculinist epistemology is, according to Hartsock, evident in the emphasis on death in scientific accounts of reproduction (as opposed to life); an existential fixation with death; as well as the deadening of women's sense of self in their role as carers. These are diverse and disputable claims. Is there a such widespread cultural fetish with death in the West? Surely the fascination with death in western culture can be explained in a less sensationalist fashion, and different interpretations can be found. Indeed, there seems to be a different interpretation of women's role as carers available in Hartsock's theory: one which emphasises the value to be found in women's experience of caring. How can this be reconciled with the (negative) deadening of women's sense of self?

I argue that these are potentially fatal flaws in feminist standpoint theory, raising the serious prospect that a science based on a feminist standpoint would be unworkable and even counterproductive. This is reinforced on further consideration of what the practice of science based on a feminist standpoint might look like.

There is little discussion of what methodologies would be adopted in a science based on a feminist standpoint. Although there is clearly a commitment to better interpretations of the real world, there is no detailed description of how a standpoint would be reflected in the methodology adopted. Moreover, whilst the ideas for a feminist sociology are instructive for the human sciences, there is a lack of similar ideas for the natural sciences. To what extent would context be explored, and how would knowledge claims be evaluated? This lack of analysis seriously weakens the case for a science based on a feminist standpoint.

On the issue of how a feminist science would be organised I have already argued that following Rose's and Hartsock's theory of a feminist standpoint rooted in experience, a feminist science based on a feminist standpoint is likely to be separated from the mainstream. This is backed up by Rose, who argues that feminist science is being practiced now, by women in the women's health and environmentalist movements. This type of women's activism takes place in reaction to science. It would follow from Rose's argument that women in science tend to be alienated from their caring principles, that there is no feminist science within scientific institutions. How then do we create a new epistemology of science based on Rose's feminist standpoint, within scientific institutions? This version of a feminist science is defined by its position outside of mainstream science, on the margins. As I have argued, for a significant challenge to science to be mounted by feminists, they must also be positioned within mainstream scientific institutions.

Feminist standpoint theorists are, however, convinced that a science based on their principles will not remain on the margins. Their vision is also utopian. Hartsock is advocating a society-wide feminist standpoint, following a feminist revolution in which parenting would be shared. This would have to be achieved before a mainstream science could be based on a feminist standpoint. I take the view that there is a distinct lack of such revolutionary potential. The requirements Hartsock sets as precursors to a feminist science are difficult to envisage (eg fully equal responsible parenting) and she offers no programme for their achievement. Just how feminists would get to the position of influence to engineer such change is difficult to imagine. There is little potential in 'waiting for the revolution'. This means a replacement feminist science based on feminist standpoint theory must be viewed as unlikely.

4.3.4 Conclusion

Feminist standpoint theories bring to the feminist analysis of science a concern to locate knowledge in the social location of the knower, challenging the traditional view of disembodied, 'objective' knowledge. They also bring an analysis of gender to the narrow economic concerns of Marxist theory. In so doing they make a significant contribution to feminist understanding of the nature of knowledge. However, I conclude that a science based on a feminist standpoint is likely to prove to be unworkable and marginalised. Most importantly a single achieved position as the basis for a feminist standpoint is difficult to envision given the differences in women's experiences.

Moreover, it is unclear what the methodologies adopted in a science based on a feminist standpoint would be. The implication is that such a science would be organised outwith mainstream science on the margins. For this reason I argue the potential for any meaningful challenge to the status quo is limited.

In the next section I move on to consider two theorists who have brought postmodernism to bear on feminist standpoint theory in an attempt to develop a more adequate theory of a feminist science.

4.4 Postmodernist Additions

4.4.1 Postmodernism and Feminism: Critique of the Feminist Standpoint

Postmodernism and feminism have an uneasy relationship. Alliances arise as theorists in both camps seek to uncover political power within the academy, and resist generalising about women's experience or the causes of their oppression (Nicholson, 1990; Flax, 1983, 1987, 1990). Deconstruction of modernist dichotomies is also favoured by feminists and postmodernists - for example, public and private, emotion and reason - because these dichotomies have played a role in women's oppression (Nicholson, 1990). On the other hand, postmodernism is viewed with skepticism by feminists. Some argue that it is dangerously apolitical and relativist (Nicholson, 1990). What do these debates mean for a feminist science?

Feminist theorists such as Sandra Harding (1986, 1991) and Donna Haraway (1985, 1988) seek to resolve some of these conflicts between feminism and postmodernism in offering a new breed of feminist epistemologies of science. Their starting point is a critique of feminist standpoint theories, where they come to different conclusions about how best to treat the legacy of modernism.

Harding makes a strong case against the gender blindness of traditional externalist and internalist histories of science as well as the post-Kuhnian sociology of science (1986, 1991). She provides a comprehensive review of the feminist critique of science, including feminist work on 'women worthies', equity, education and androcentrism in science (1986, 1991). She then argues that the development of feminist epistemologies of science is the next step in the feminist critique, because these have so often been overly-accepting of the traditional positivist epistemology of science. She characterises feminist empiricism as positivist, but is concerned to see more women in science to 'police' sexist bias. Harding argues that this approach has a 'radical future' given the emphasis placed on women's involvement. She then turns to feminist standpoint theory which she considers to be more radical, and useful, in the promotion of a feminist science. Note that, despite the apparent linear progression in feminist ideas, Harding argues that each has a place in developing a feminist science, and she wishes to see them work simultaneously.

Harding's main argument is for the development of a feminist 'emancipatory epistemology' of science (Harding, 1986, p18). She treats epistemology as 'mediation' on feminist theory and practice, and rejects the privileging of understanding of feminists' practice of science over the incorporation of wider feminist theory of knowledge into feminist epistemology of science (Harding, 1986, p140). Whilst not aiming for a 'master theory' of science, the goal of a radical reconstruction of science is central to her analysis (Harding, 1986, p186). Her definition of epistemology incorporates wider social issues, asking:

> Who can be subjects of socially legitimate knowledge? ... What kinds of tests must beliefs pass in order to be legitimated as knowledge? ... What kinds of things can be known? Should all ... situated knowledge be regarded as equally plausible or valid? What is the nature of objectivity? ... What is the appropriate relationship between the researcher and the research subjects? (Harding, 1991, p111).

She continues:

> As these questions indicate, the grounds for whole classes of knowledge-claims are at issue in the case of feminist research ... Thus feminist research in biology and the social sciences raises distinctively epistemological issues - that challenge the conceptual framework - its moral, political and metaphysical assumptions - within which the dominant Anglo-American epistemology has posed its concerns (Harding, 1991, p111).

Harding therefore places epistemology of science (social and natural) centre stage in her arguments for a feminist science.

Harding accepts Flax's (1987) criticism of feminist standpoint theories, accepting that there are many partial perspectives, and no one way in which patriarchy has permeated thinking (Harding, 1986, p154). Nevertheless, she is concerned to achieve 'more true knowledge', which she sees as being at odds with Flax's postmodernist position (Harding, 1986, p155). This is the paradox which Harding seeks to resolve in combining feminist standpoint theory and postmodernism. She aims to 'reinvent' the dichotomy between men and women, and make it liberatory instead of oppressive.[18] Harding aims to resolve these issues in her treatment of feminist standpoint, and her concept of strong objectivity, discussed in section 4.4.2.

Haraway comes to the question of a feminist science from a different perspective. As a trained biologist, who moved into history of science, her main work has been a critique of gender in the science of primatology (Haraway, 1989). Here she develops a methodology for the sociology of science which treats science as 'story telling'. She is informed by a political goal to retell Western origins stories that rationalise their global economic and cultural domination. Epistemological concerns are secondary for Haraway, and she is suspicious of a replacement science, arguing that such a project carries the danger of simply reconfiguring power relations into a new form of inequality. However Haraway does envision change in science by developing a political manifesto for knowledge-seeking (Haraway, 1985, 1988), although she is less explicit about the particulars of this goal. She faces a similar dilemma to Harding's when she describes feminists as trapped between two poles - social constructivism and appeals to the 'real' world (feminist empiricism and standpoint theory):

> So, I think my problem and "our" problem is how to have *simultaneously* an account of radical historical contingency for all knowledge claims and knowing subjects, a critical practice for reconstructing our own "semiotic technologies" for making meanings, *and* a no-nonsense commitment to faithful accounts of a "real" world, one that can be partially shared and friendly to earth-wide projects of finite freedom, adequate material abundance, modest meaning in suffering, and limited happiness (Haraway, 1988, p187).

Here Haraway links radicalism with both social constructionism and realism.

---

[18] See Harding's discussion of King et al (1976) for a discussion of a parallel approach to race (Harding, 1991, p154).

In *Primate Visions* (1989) Haraway considers Japanese primatology (as described briefly in Chapter 3) and highlights a similar flaw in the concept of a women's or feminist standpoint to the one Harding raises. She notes that although Japanese science was more 'holistic' (a supposedly feminist attribute) it was compatible with masculinism in epistemology and male domination in science. Haraway argues that any claim to a particular standpoint, based on race or sex, suppresses difference to achieve unity (in opposition to the dominant race or sex). Thus, Haraway concludes that feminist arguments for empathy and holism as a replacement to masculine science involves a fiction which papers over differences in masculine science; the case of Japanese primatology demonstrates that science can involve holism and reductionism, as well as alliances between so-called feminist and masculinist values. Haraway therefore problematises the feminist aim of replacing masculinist stories with feminist ones.

Haraway's solution to this dilemma is more postmodernist than Harding's, as we shall see in section 4.4.3. She sees deeper tensions between postmodernism and feminist standpoint theories. In her 1988 paper she raises three issues. First, she is uncomfortable about the notion of the ideal vantage point of the subjugated, seeing the danger of romanticising and even appropriating such a vision. Second, she rejects the privileging of these forms of knowledge on the grounds that because they are a function of the complex sociopolitical environment in which we live they cannot be purely advantageous, and must also have disadvantages. Third, the difficulty in 'seeing from below' is recognised by Haraway, as is the problem of positioning oneself simultaneously in all, or wholly in any, of the privileged subjugated positions. In short Haraway is arguing that there is no single feminist standpoint.

4.4.2 Feminist Standpoint and Strong Objectivity

Harding's solution to the tensions between modernism and postmodernism involves developing the feminist standpoint theory as a justificatory strategy (1991).

Her main argument is that science would benefit if scientists (including men) developed the ability to think from women's lives, the basis for her version of a feminist standpoint. This requires that women articulate the 'gap they feel between their experience and the dominant conceptual schemes' (Harding, 1991, p70). Scientists should start from women's lives,

> increasing the objectivity of research by bringing scientific observations and the perception of the needs for explanation to bear on assumptions and practices that appear "natural" or unremarkable from the perspectives of the lives of men in the dominant group ... [this] makes strange what appears familiar, which is the beginning of any scientific inquiry (Harding, 1991, p150).

Harding identifies five main grounds for a feminist standpoint, relating to differences in the social position of men and women. Note that she considers these complementary, not competing. First she adopts Hartsock's and Rose's analysis on the sexual division of labour (see section 4.3). She also argues that other standpoint theories are relevant in this context: for example, Ruddick's 'maternal thinking' theory (Ruddick, 1989); Gilligan's theories on moral reasoning (Gilligan, 1982); and Belenkey et al's 'women's way of knowing' theory (Belenkey et al, 1986). Harding makes an important distinction between the experiences, perspectives, and claims of women and a feminist standpoint:

> For a position to count as a standpoint, rather than as a claim - equally valuable but for different reasons - for the importance of listening to women tell us about their lives and experiences, we must insist on an objective location - women's lives - as the place from which feminist research should begin (Harding, 1991, p123).

The second set of grounds for a feminist standpoint comes from Patricia Hill Collin's 'outsider within' theory (Collins, 1986). Women are strangers to the oppressors' social order, and this strangeness is valuable because it acts as a fresh and illuminating standpoint from which to criticise the dominant conceptual schemes.

Third, women's oppression gives them less interest in ignorance:

> This argument can be put in terms of what women, and especially feminist women, can come to be willing to say. But it is less confusing if it is put in terms of what can be seen if we start thinking and researching from the perspective of the lives of the oppressed (Harding, 1991, p126).

A fourth, and related, point is that 'women's perspective is from the other side of the "battle of the sexes"' (Harding, 1991, p126). This perspective generates less false knowledge, but can only be achieved through struggle:

> This need for struggle is emphasised by the fact that a feminist standpoint is not something that anyone can have simply by claiming it. It is an achievement. A standpoint differs in this case from a perspective which one can have simply by "opening one's eyes" (Harding, 1991, p127).

This means that not all women will adopt a feminist standpoint, but some feminist men will.

Harding draws on Dorothy Smith's (1987) theory of a feminist sociology, where she argues that women's perspective is from everyday life, and women's labour shapes men's thought processes as it allows men to remain in the abstract realm. Thinking from women's lives, on the other hand, would mean knowledge grounded in everyday life. A sixth point draws on both Collins (1986) and Smith (1987) to argue for a 'line of fault' which develops from women scholar's 'bifurcated consciousness' - a disjuncture between women scholar's everyday lives, and their role in academia - this can be a resource for new thinking.

Fifth, Harding argues that this is the right time in history for the development of a feminist standpoint, drawing parallels between the Marxist conception of the proletarian standpoint and a feminist standpoint where women and men are sex classes in the present sex/gender system. Women's economic, political and sexual gains make this the time to bring about change to a feminist science. Harding advocates 'democratic, participatory politics' within science, arguing for a diversity of people and approaches (Harding, 1991, p124).

Harding also responds to two important criticisms of feminist standpoint: that it is essentialist and excessively foundationalist.

On essentialism Harding argues that there are several strategies for justifying the notion of a feminist standpoint which do not depend on claims about mothering (which have been criticised for essentialism). Harding further argues that the feminist standpoint theorists are not Eurocentric as they are involved in anti-racist activism alongside women of color. Feminist standpoint theory has been used by to develop a black women's standpoint - eg by Collins (1986). So standpoint theories can be useful to many different oppressed groups. Harding's main point is that there are resources within standpoint theories to combat essentialising tendencies. Most significantly, her emphasis on bringing critical reflection on how the observer's social location determines the way they observe into science, allows for an understanding of difference to be part of the evidence for a particular theory.

Harding's response to the charge that feminist standpoint theory is excessively foundational or "too epistemological" is also important. She responds to the causal symmetry argument of the Edinburgh strong programme (Bloor, 1976) by arguing that one can distinguish between more false and less false knowledge by looking to the social conditions of the knowledge production. Thus, in the case of feminist standpoint,

> it is the objective perspective from women's lives that gives legitimacy to feminist knowledge ... this is a reason to get our inquiry processes and institutions inserted into the kinds of social contexts that have tended to cause less false rather that more false beliefs (Harding, 1991, p167).

Elsewhere (1986) Harding has argued that the natural science would be more usefully conceptualised as part of the social sciences, rather than the other way around. This would allow the physical sciences to adopt the critical practices of the social sciences and therefore improve the quality of the knowledge produced by putting it in context. This may be part of the institutional changes involved with a feminist science.

Central to this type of inquiry Harding proposes is strong objectivity, which involves

> systematic understanding of powerful background beliefs ... [and] requires causal analyses of micro processes in the laboratory and macro tendencies in the social order which shape scientific practice ... [this] permits a robust notion of reflexivity (1991, p149)

This does involve cultural, sociological and historical relativism, but not judgmental or epistemological relativism according to Harding (see 3.3.3 for a discussion of relativism). The goal is to arrive at less false beliefs rather than any one true position. It is essential for feminists to remain on Enlightenment ground because of their aim of social progress (Harding, 1991, p186).

Furthermore, she notes that this is an,

> epistemological metascientific issue rather than one to do with any particular science ... it is more like a directive to operationalise theoretical concepts than a directive to operationalise in a certain way some particular theoretical notion within physics or chemistry (1991, p156).

Strategies for strong objectivity would therefore have to be developed within each programme, although Harding argues that plenty already exist in biology and in social science.

In her defence of postmodernist aspects of her theory, Harding makes a distinction between 'postmodernism and Postmodernism', arguing that the critical tendencies in the former are of use to feminism, but that the set of claims and practices of the latter can be criticised for being epistemologically relativist. Feminists must develop a 'robust and principled ambivalence' to postmodernism (Harding, 1991, p186). At the core is a commitment to understanding how knowledge is socially located and identifying ways in which less false knowledge claims can be distinguished from more false claims.

Now I consider Haraway's contributions to feminist science theories.

4.4.3 Cyborgs and Situated Knowledge

In a paper entitled, 'A Manifesto for Cyborgs: Science, Technology, and Socialist Feminism in the 1980s' (1985), Haraway develops the metaphor of the cyborg to make proposals which concern a feminist science. The cyborg is a hybrid between machine and human; humans, it is claimed, have become cyborgs in this high technology age of informatics, communications, robotics and new reproductive technologies. Haraway argues this can be used as an 'imaginative resource' to develop a political identity which defies boundaries between animal and humans, organism and machine, physical and non-physical. It contributes to a politics of fusion and unity based on coalitions, not on any essential shared identity. The importance of recognising partial and distinct perspectives is stressed, but not without noting the importance of the search for shared perspectives. An example might be the shared oppositional consciousness of 'women of colour'.

Haraway develops these ideas in relation to science in a later paper. She describes feminists' dilemma in the following way:

> In our efforts to climb the greased pole leading to a usable doctrine of objectivity I and most other feminists in the objectivity debate have alternatively, or even simultaneously, held on to both ends of the dichotomy, which Harding describes in terms of successor science projects versus postmodernist accounts of difference and I have sketched ... as radical reconstructivism versus feminist critical empiricism. It is, of course, hard to hold on to both ends of a pole, simultaneously or alternatively. It is, therefore, time to switch metaphors (Haraway, 1988, p188).

Haraway's preferred metaphor in this 1988 paper is vision, which she uses to develop her concept of situated knowledge. This is where partial perspectives are subjected to critical reflection:

> Feminist objectivity is about limited location and situated knowledge, not about transcending and splitting of subject and object. In this way we might become answerable for what we learn how to see (Haraway, 1988, p190).

Individuals share their vision by the 'loving care people might take to learn how to see faithfully from another's point of view' (Haraway, 1988, p190). Furthermore, 'webs of connections called solidarities in politics and shared conversations in epistemology' (Haraway, 1988, p191) are formed. This helps us to become more aware of ourselves:

> The split and contradictory self is the one who can interrogate positionings and be accountable, the one who can construct and join rational conversations and fantastic imaginings that change history. Splitting, not being, is the privileged image for feminist epistemologies of scientific knowledge. 'Splitting' in this context should be about heterogeneous multiplicities that are simultaneously necessary and incapable of being squashed into isomorphic slots or cumulative lists ... The knowing self is partial in all its guises, never finished, whole, simply there and original; it is always constructed and stitched together imperfectly, and *therefore* able to join with another, to see together without claiming to be another. Here is the promise of objectivity: a scientific knower seeks the subject position not of identity, but of objectivity, that is partial connection (Haraway, 1988, p192-3).

Haraway therefore argues that:

> a splitting of senses, a confusion of voice and sight, rather than clear and distinct ideas, becomes the metaphor for the ground of the rational (Haraway, 1988, p196).

She therefore directly challenges the privileging of traditional notions of rationality.

Another important feature of Haraway's analysis is her insistence on treating objects as actors, like Latour, rejecting their treatment as passive and inert. This granting of agency includes the body. This ties into Haraway's self confessed nervousness about the sex/gender distinction which she argues is part of an 'appropriationist logic of domination' (Haraway, 1988, p189) where sex becomes a resource for its 're-presentation as gender' (ibid). The alternative is situated knowledge:

> Situated knowledge requires that the objects of knowledge be pictured as an actor and agent, not a screen or a ground or a resource, never finally as slave to the master that closes off the dialectic in his unique agency and authorship of 'objective' knowledge. The point is paradigmatically clear in critical approaches to the social and human sciences, where the agency of people studied itself transforms the entire project of producing social theory. Instead, coming to terms with the agency of the 'objects' studied is the only way to avoid gross error and false knowledge of many kinds in these sciences (Haraway, 1988, p198).

Haraway treats the world as an 'active entity' (ibid), and argues that 'no particular doctrine of representation or decoding or discovery guarantees anything' (Haraway, 1988, p190). Examples of this type of approach in feminism include ecofeminism, with its concern to represent the world as active and not a resource; and feminist biologists' reconstruction of the body:

> Difference is theorised *biologically* as situational, not intrinsic, at every level from gene to foraging pattern, thereby fundamentally changing the biological politics of the body (Haraway, 1988, p200).

In this way nature is characterised as a 'coding trickster with whom we must learn to converse' (Haraway, 1988, p201).

Haraway disrupts the traditional boundaries between rationality and irrationality; objects and subjects; sex and gender, to argue for a science based on respect of difference; recognition of complexity, and a humble approach to the natural world.

4.4.4 Practice

My starting point in this section is a consideration of the implications of Harding's and Haraway's theories for the feminist scientist. I then consider issues of methodology, organisation and the relationship between science and society.

Harding's goal of bringing an understanding of women's lives, and women's voice, into science is extremely important. She is right to raise postmodernist criticisms of standpoint theory whilst retaining the goal of better knowledge. However, I do not feel that she has resolved these tensions: in my view feminist standpoint theory remains problematic. The most pressing problem is the difficulty in translating Harding's so called 'emancipatory epistemology' into practice. This brings into question the fundamental premise of Harding's work: if epistemology cannot be translated into practice how can it be liberatory? I now explore each of the contradictions in turn.[19]

First, I would argue that Harding's mixture of theories regarding differences in women's and men's social positions raises problematic contradictions. The distinction Harding makes between experience/perspective and standpoint is unclear. Indeed, at times she even uses the terms interchangeably. An example to illustrate this problem is her adoption of the concept of bifurcated consciousness: the 'line of fault' for women scholars, particularly feminists, which generates more true knowledge than that based on a unitary consciousness. What makes this standpoint different from a perspective based on experience? Although Harding argues a standpoint is related to experience the relationship is unclear. How does one move from having particular experiences or perspectives to a standpoint based on the objective location of women's lives?

---

[19] Whilst Harding argues that contradictions should be viewed as positive (1991) I am not convinced that this is always the case, or a robust enough defence of her approach. The contradictions therefore require further examination before their implications can be fully assessed.

Harding's theory involves the problems associated with each of the theories from which it is drawn. Her use of object-relations theory/maternal thinking is especially troublesome to me and I find her defence against accusations of essentialism inadequate.[20] Eurocentrism in standpoint theories based on object-relations is not avoided because individual feminist scholars are involved in anti-racist activism. The fundamental problem with psychoanalytic theories is their false universalism. based on inadequate grounding in an understanding of the experiences of men and women (which, of course, depend on class and race), in particular their psychic-essentialism. This type of understanding does not come automatically from participation in activism, but requires the aim of linking activism and theory, what Connell has called strategic theorising (Connell, 1983).

Harding's mixture of different feminist theories does not produce a coherent theory. On the one hand her use of object-relations and 'maternal thinking' feminist theories, amongst others, implies that a feminist standpoint is rooted in experience, both biological and social. On the other hand, Harding is making an unclear distinction between experience and standpoint. Instead, much of her theory implies that standpoint and experience are closely related. Following on from this, the same criticism of certain psycho-analytical feminist theories for false universalism can be made of feminist standpoint theories. Women do not have one standpoint/experience but many. This prevents the adoption of one single feminist standpoint by feminist scientists, but leads to different feminist standpoints, depending on experience. (Once more this does not negate any commonality in women's standpoints, just introduces important differences).

My criticism leads me to conclude that a feminist standpoint is a problematic theoretical stance, and is difficult to translate into the practice of a feminist science. This does not, however, negate Harding's entire contribution to feminist theory of science. The concept of strong objectivity remains. Indeed, I would suggest that

[20] Cowan is equally unconvinced by Harding's solution to essentialism. See Cowan (1995).

Harding does not need to provide a theory of one feminist standpoint in order to fulfill her commitment to an epistemology which seeks to identify more true knowledge. For this reason I now consider the meaning of strong objectivity in practice.

On methodology, like Bleier, Harding makes a convincing argument that science should be more reflexive, and should take the context of scientific knowledge claims more seriously. Her concept of strong objectivity is, in this sense, laudable. But, how would strong objectivity be put into practice? The key to this theory is the possibility of distinguishing between more and less true knowledge based on its social location. This, in turn, depends upon a systematic understanding of micro and macro factors shaping the knowledge. However, social scientists' grasp of the way the social and the natural are reflected in scientific knowledge does not involve distinguishing between the social and the natural, as illustrated in the concept of the 'seamless web' in sociology of technology (see Hughes, 1983). Relativism remains a problem for social scientists seeking to understand knowledge claims in science. Harding argues for separating cultural, historical and sociological relativism from judgmental relativism. However, as we have seen in Chapter 3, this is often difficult. The natural is always seen through social lenses.

My third criticism concerns the organisation of science. With a methodology based on strong objectivity in natural science, would the scientists be judging between competing knowledge claims, or would social scientists take a more involved role? If the traditions of peer review by scientists is followed they would need to be trained to take a sociological approach to knowledge claims, to justify their particular interpretation. If social scientists are to become involved to judge scientists' claims reorganisation of scientific disciplines is required.

Harding has argued that there are important structural issues relevant to epistemology, which would require changes in science at the institutional level, eg natural sciences as a subdiscipline of social sciences. However she fails to discuss how social sciences should be the paradigm of scientific inquiry (as opposed to physical sciences). She even goes so far as to argue that she does not wish to offer directives about how to operationalise strong objectivity in the different disciplines of science. Arguably suggesting an agenda for strong objectivity in practice is a difficult task, which Harding is right to be cautious over. Nonetheless, her failure to think critically about what strong objectivity might mean in practice, fundamentally weakens her theory.[21]

Fourth and finally, Harding's is a utopian vision of change. Her emphasis on the emancipatory potential of epistemology implies that feminist change will come from inside science and graduate outwards, affecting society. It also implies that there must be a change in theory (epistemology) before a change in the practice of science. I disagree with both these features of Harding's argument. It seems unlikely to me that widespread societal change will result from a change in science. Surely science is also a product of society, so change in science requires some level of societal change? Note that this does not mean I simply advocate waiting for changes in society to change science, a position which I criticised in section 4.3.3, but am arguing that the opposite extreme from this approach - waiting for science to change society - is equally problematic. Instead I suggest that a more flexible approach to change, from both within and outwith science, is likely to be more realistic and more effective. Similarly, as epistemology and theory are products of social practice, change in epistemology requires change in the practice of science and vice versa. The two way relationship between science and society; theory and practice requires exploration. This is an important theme in this thesis, and will be considered further in more detail in Part 3.

---

[21] For example, Harding's argument about strong objectivity in biological science because of its more local level of research does not follow, given the international level of much of biological research, as is the case with the Human Genome Project (see Rose, 1994). Cowan also criticises Harding for failing to think about the 'nitty gritty' of her epistemological claims in terms of the practice of science - Cowan (1995).

I now consider what Haraway's version of a feminist science might mean in practice.

First, Haraway's feminist scientist does not need to subscribe to one particular feminist politics or adopt one feminist standpoint. This avoids the flaws of false universalism identified earlier. However, her use of the postmodernist concept of coalition politics, to replace identity politics, has its problems in terms of political strategy. The main one is the danger of coalitions leading to single-issue politics. Obviously coalitions are fluid and change over time. Does this involve the break-down of a coherent political movement? Factionalisation within the feminist movement has certainly seemed, in recent years, to lead to single-issue politics, and no sense of unity around a core set of issues. Surely a strong and influential feminist science requires some form of unity, or it will disintegrate?

This brings me onto my second point: if situated knowledge were to be adopted as a methodology within science it could lead to a lack of consistency in judgment of knowledge claims. With all the splitting and confusion of voices Haraway calls for, do we end up with a cacophony; do we lose coherent theories in science? Harding's call for 'less false beliefs' is relevant here. This implies some sort of shared value system in science around which scientific claims are judged. When these values rest upon a call for difference what criteria can usefully be applied? Although Haraway is rejecting relativism in theory I am unsure about whether there would really be a corresponding rejection in practice if her theory is implemented.

The implications of situated knowledge for scientific methodology are difficult to conceptualise, particularly in terms of the experimental or physical sciences. Haraway argues that objects should be treated as actors. This is easy to see in the social sciences, and in observational biology. However, experimental science does not involve a passive observational approach, but an active manipulation of the objects of study (see Rose, 1994 for a discussion of the differences). How do we give a (dead) rat's liver, or an electron, agency? Would Haraway's feminist science involve the abandonment of animal experimentation, or even all experimentation, in favour of a less interventionist, more deductive science?

The other issue is how do scientists examine the context of understanding in the 'harder' sciences, eg chemical interactions? Perhaps gender symbolism is deep rooted and difficult to uncover, perhaps it not as relevant in all the physical sciences as the human sciences. It is difficult to imagine what it means to think from other's perspectives around highly theoretical physical sciences, which have little obvious practical relevance. Or maybe a feminist science would not involve such theoretical 'pure' science, focusing more on applied science. All of these factors are unclear in Haraway's work.

Third, how should a feminist science based on situated knowledge be organised? As Longino and Hammonds point out (1990, p211), Haraway argues that the recognition of partiality involves 'the historical location of discourse, tools and "subjects"' (Haraway, 1988, p589). Longino and Hamnmonds continue:

> Subjects come into being in social fields of meaning, and discourses are themselves social. Partiality in this sense involves the potential of connection with other discourses to generate other partial and mutable systems of understanding ... It is not the individual recognition of partiality ... but the subjection of hypotheses and theories to multivocal criticism that makes objectivity possible ... reflexivity is community-wide and the openness of partial knowledge facilitates transformation (Longino and Hammonds, 1990, p212-3).

Longino's reading of situated knowledge at the institutional level, concerns critical interaction amongst scientists. (Note that I would still argue, as previously, that this requires some form of situated knowledge at the individual level: as Haraway's split and contradictory self implies.) However it is unclear how this would be developed in science. How do people develop such a style? Does this require scientific training, or more fundamental changes, in parenting practices, for example (if we accept object-relations theory)?[22]

Finally, it is unclear what the relationship would be between Haraway's feminist science and society. Important questions raised earlier, concerning the viability of a feminist science without a feminist society and the involvement of the wider public in science are not addressed. I am unable to find any implicit assumptions in Haraway's work which might help in answering these questions.

4.4.5 Conclusion

Following this first level theoretical analysis I conclude that neither Harding's or Haraway's feminist epistemologies translate well into practice. Harding's criteria for a feminist scientist are likely to be unworkable. I argue that her adaptation of the notion of a feminist standpoint does not overcome the problems identified in section 4.3.4: difficulty with the notion of one feminist standpoint; and the way different standpoints are rooted in different experiences. Women may share common experiences and perspectives on certain issues, but, in other areas their experiences and perspectives are bound to be different. This implies a feminist science cannot be based on a single feminist standpoint. In contrast, Haraway's feminist science, based on fractured identities, may be unworkable precisely because of her emphasis on difference. The danger is that in a science based on fractured identities, consensus will be impossibly compromised and feminist scientists will be unable to work as a coherent group.

This relates to the problems I raised concerning methodology. Harding's 'strong objectivity' and Haraway's 'situated knowledge' both seek to find a compromise between objectivism and relativism. However their solutions are not

[22] This is drawn from an earlier discussion of Hartsock (1983) whose emphasis on object-relations theory in relation to scientific knowledge led to her call for a revolutionary change in parenting structures, in a move towards a feminist science.

unproblematic. The danger in emphasising different perspectives (ie relativism) is the threat to coherent grounds of knowledge claims. Moreover, both raise the issue of deconstructing the basis for knowledge claims without explaining the mechanisms. How would scientists analyse the 'seamless web' of science and their position therein? What are the mechanisms for treating objects as actors in practice, particularly in the hard sciences?

Organisational changes necessary to achieve Harding's and Haraway's feminist science are also unclear. What changes would be required to generate multivocal criticism of scientific theories, and how would social scientists and natural scientists interact?

Finally the relationship between science and society is ambiguous. Harding seems to be arguing that changes in science would change society, but a one way relationship is unlikely since science is a product of society.

These are important issues in developing a practical framework for a feminist science and will be examined further in my empirical research and analysis.

4.5 Feminist Empiricist Science

4.5.1 Feminism and Empiricism

Empiricism tends to be viewed with skepticism by the feminist theorists of science detailed in sections 4.3 and 4.4. For many it is seen as part of a masculinist epistemology, and inevitably bound up with the positivist deceit of value-free knowledge. In contrast, Nelson and Longino both argue that empiricism has more to offer a feminist science than we might think. In this sense they share the view of feminist critics such as Fausto-Sterling and Fee, who seek a compromise between orthodoxy and radicalism. I therefore return to consider what empiricism means for a feminist science in more depth, focusing on the work of Nelson and Longino.

Longino criticises the popular feminist rejection of empiricism, arguing that Harding's version of feminist empiricism is a 'straw woman' (Longino, 1988). She argues that feminist empiricists do not claim that women or feminists are more likely to produce unbiased results, and are far from content with existing methodologies in science (eg the review of Anne Fausto-Sterling's position in section 4.1.1). Instead their empiricism is based on a commitment to critical evaluation of knowledge claims based on the available evidence.

Nelson also argues that contemporary empiricism is different from the caricature, based on traditional logical positivist empiricism:

> Empiricism, which is at bottom a theory of evidence, is one way of understanding [scientific accounts]. And as a theory of evidence empiricism is far from bankrupt (Nelson, 1990, p6).

Both Nelson and Longino are critical of feminist epistemology of science, especially feminist standpoint theories. They aim to provide a new theory of a feminist science, based on the practice of science instead of the product - scientific knowledge. Longino notes that this approach emphasises the practical, active character of scientific inquiry, and hence the way in which science is social (Longino, 1989, p18). It involves asking questions about the goals and criteria of scientific inquiry, for example, and resists the treatment of scientific knowledge as somehow disembodied from, and uninfluenced by, social practices. Longino argues:

> By focusing on science as practice rather than content, as process rather than product, we can reach the idea of doing a feminist science through that of doing science as a feminist (Longino, 1989, p188).

I now consider the approach taken by Nelson and Longino in more depth.

4.5.2 Feminist Empiricist Science

Nelson and Longino argue that for feminist empiricism to be successful the traditional epistemological framework must be updated with an understanding of how science is socially constructed. Both reject what Longino calls, 'epistemological reductionism' (Longino, 1989, p226). The basic epistemological unit should be the community of knowers, not individual knowers. They emphasise the social location of knowledge producers, and its influence on the knowledge they produce. Nelson draws on Jagger (1983) to argue:

> Even "ascribing" these perspectives [feminist and androcentric] to individuals abstracted from social and political context is at best artificial, if indeed, we could make sense of "selves" so abstracted. In any event ascription would be unhelpful. We cannot reasonably credit any individual with the assumptions, research questions, or methodologies we have been considering - feminist or androcentric. Androcentric assumptions, no less than feminist assumptions, incorporate and build from social experiences, from public ways of conceptualising sex/gender, from experiences of sex/gender, and other political experiences, and from the practices from which such conceptualisations cannot be separated. Nor am I suggesting that there is "a" feminist perspective or "an" androcentric perspective at issue; each kind of perspective can be discerned in a variety of assumptions and views (Nelson, 1990, p267).

She continues that these perspectives are relative to groups or subcommunities within the larger society. Their acceptability is limited to the subcommunity.

In the case of a feminist science community, Nelson continues, scientists and philosophers should be involved. Empiricism, it is argued, is the key to bridging the traditional gap between these groups. Scientists must be brought into the dialogue as,

> the point of feminist science criticism, must, in the end, be to change science, and changing science requires changing the practice of scientists ... Science as currently practiced is too entrenched, too pervasive and too successful to be simply abandoned (Nelson, 1990, p6).

Nelson highlights the importance of reflecting on the role, aims and effectiveness of science in today's society, when thinking about the meaning of a feminist science. As previously noted in section 4.2.1, feminists could turn the function of science as producer of ideology to their advantage, or may instead choose to expose the ideological role of science in order to defy it. The commitment to understanding nature is also valued by feminist scientists. Many reject the concept of 'throwing the baby out with the bath water' when thinking about a feminist science. Instead they favour utilising some of the methods and practices of existing science. This has parallels in Longino's recognition of the need to change science from within.

Both Longino and Nelson argue that feminist scientists need not base their science on a feminist standpoint. For Longino standpoint theory is a circular argument (and therefore flawed):

> Both forms of standpoint theory [Marxist and feminist] share the same weakness. Since neither wage labourers nor women share a common perspective, it becomes necessary to identify a subclass within each of those groups whose perspective does form an appropriate standpoint. However, the theory one is attempting to vindicate by a standpoint methodology is required to identify this subclass, thus making the procedure circular (Longino, 1989, p11-12).

Later, Longino continues her criticism:

> women are too diverse in our experiences to generate a single cognitive framework ... In addition, the sciences are themselves too diverse for me to think that they might be equally transformed by such a framework (Longino, 1989, p188).

The evaluation of knowledge in feminist standpoint theory, in terms of the extent of its grounding in women's social position, ie outside of science, is also rejected by Nelson. Instead she argues, along with Longino, that the justificatory grounds for knowledge should be located inside the conceptual scheme of science (Nelson, 1990, p8-9). The argument promoted by standpoint theory, that only feminists or women can know certain things, is rejected by Nelson, on the grounds of lack of evidence.

She focuses on the gap between the understanding of feminists and scientists, which feminist standpoint theorists seek to explain by appealing to an inevitable epistemological chasm. This chasm, according to Nelson, is neither inevitable or unbridgeable.

Moreover, Longino rejects the conflation of feminist with feminine (also discussed by Keller). She argues that the feminist focus on the content (rather than the practice) of science leads them to argue that feminist science theories might encode a particular (feminine) world view, or that women have certain traits that should be incorporated into science, eg a focus on complexity (cf Rose, 1983; Bleier, 1986). Longino argues that this alienates women scientists because it is seen as 'new clothing for the old idea that women can't do science' (Longino, 1989, p188). In any case, feminists should recognise that, 'women are constructed to occupy positions of social subordination ... we should not uncritically embrace the feminine' (Longino, 1989, p188).

Longino's and Nelson's rejection of feminist standpoint theory does not lead to their adoption of relativism. Indeed, the rejection of relativism is the second important point about feminist empiricism, which stresses critical evaluation which leads to knowledge being constrained by evidence:

> this view of experience and the constraints it places on justifiable beliefs leads to a minimalist form of realism. There is a world independent of our senses with which those senses interact to produce our sensations and the regularities of our experience. There is "something out there" that imposes limits on what we can say about it. Once we have decided on a system for measuring movement, the speed of an object is not arbitrary. The sort of things we measure, however, will change as our needs, interests and understanding change. The processes that occur in the world will continue regardless of changes in our descriptive systems. Indeed it is that very constancy that enables us to develop a descriptive system at all (Longino, 1989, p222).

This position, that nature is 'out there' and that we can only, at best, approximate its make-up, is common to all of the feminist epistemologies reviewed in this chapter.

Feminist critics and many of those in the radical science movement and sociology of science share this position. However, Longino places greater emphasis on solving the issue of judgmental relativism. She claims that judgmental relativism can be avoided, ie it is possible to distinguish between better and worse beliefs and values in science. Note that Longino and Nelson agree on this point, but differ on how to evaluate values and beliefs.

Longino advocates 'contextual empiricism', ie starting from the position of contextual, value-laden research. This means deliberately bringing feminist views into science so that a feminist science is doing science as a feminist. Longino uses the example of research in the biology of behaviour, contrasting a linear model of hormonal determined behaviour with a more complex model which focuses on the interaction of physiological and environmental factors in shaping behaviour (drawing on her earlier work, Longino and Doell, 1983). This view of behaviour includes the potential for self-modification. She argues that commitment to one or other of these two models is strongly influenced by beliefs and values. The second model is more acceptable to feminists because of their emphasis on women's subjective experience and their potential for change:

> feminism is about the expansion of human potentiality. When feminists talk of breaking out and do break out of socially prescribed sex roles, when feminists criticise the institutions of domination, we are thereby insisting on the capacities of humans ... to act on perceptions of self and society and to act to bring about change in self and society on the basis of these perceptions ... And so our criticism of theories of the hormonal influence or determination of so-called gender role behaviour is not just a rejection of the sexist bias in the description of the phenomena ... but of the limitation on human capacity imposed by the explanatory model underlying such research (Longino, 1989, p190).

Longino suggests that feminists should allow their political commitments to guide their choice of particular models in science, not simply aim to uncover sexist bias. Crucially, she appears to reject any form of 'letting the material speak' (as in the case of Barbara McClintock):

> [we] should not wait for such a framework to emerge from the data ... Instead of remaining passive to the data and what the data suggests we can therefore acknowledge our ability to affect the course of knowledge and fashion or favour research programs that are consistent with the values and commitments we express in the rest of our lives (Longino, 1989, p191).

Moreover, to remain passive to the data also allows for the prevailing gender ideology to shape interpretation covertly.

Nelson, on the other hand, argues that knowledge and beliefs should be subject to empirical evaluation, ie scientists can evaluate the distortion of their picture of 'nature' via empirical methodologies. This is developed from Quine's argument (1960) that scientific knowledge cannot be isolated from common-sense knowledge; the two are fundamentally interdependent. Common-sense theories are part of the evidence for science theories, and as such, must be subject to empirical control. For example, there is evidence that male domination is neither universal or natural which can be marshalled to challenge the implicit assumption of male domination in much scientific theorising. This means that Nelson rejects Longino's position, outlined above, arguing that she is wrong to evaluate beliefs on the basis of their social usefulness, but should evaluate them on the basis of empirical evidence.

Nelson's 'naturalised epistemology' aims to 'explain the "how" of successful theorising' (Nelson, 1990, p292) and involves a type of critical self reflection on one's social identity - on the social, sex/gendered, racial, class, and political experiences and beliefs that one has as a member of a community.

Despite this difference, both theorists agree that feminist science involves doing science as a feminist and both share the major goals of empiricism. Moreover, both argue feminist science should be continuous with existing practice:

> the development of "new" science involves a more dialectical evolution and more continuity with established science than the feminist language of scientific revolutions implies ... in particular, only frameworks that make

possible ordered interactions with a particular scientific subject matter will ever get serious attention (Longino, 1989, p193).

Note here the commitment to an organised step-by-step scientific method.

Nelson and Longino have different views on how science is organised which lead to different views on the organisation of a feminist science. Nelson argues against Harding's separation of physics from the other sciences, on the grounds that physics shares meanings with other theories and disciplines. She continues:

> thus it is possible, however unlikely it seems now, that changes in other of our theories will reverberate with sufficient resonance through the network of our going theories, to carry with them a need for a different logic, a different mathematics, or a different physics (Nelson, 1990, p252).

Nevertheless some sciences, eg mathematics, are more 'insulated' from values. This is:

> due to the fact that they do not face sensory experiences directly, but do so indirectly "via" more "low-level" theories. Their insulation is also due to their deep connection with the bulk of our other going theories. And in general scientific theories are more well insulated than common sense theories because they represent higher theoretical ground - that is, they systemise common-sense theorising (Nelson, 1990, p246).

Longino rejects this unity of science and favours theoretical pluralism, arguing feminists should:

> think through a particular field and try to understand just what its unstated and fundamental assumptions are and how they influence the course of inquiry. Knowing something of the history of this field is necessary, as is continued conversation with feminists. The feminist intervention will be local, that is specific to a particular area of research ... The accretion of such interventions of science done by feminists ... and by members of other disenfranchised groups, has the potential, nevertheless, ultimately to transform the character of scientific discourse (Longino, 1989, p193-194).

Both Longino and Nelson consider feminist critiques of biological sciences as the most appropriate focus for a feminist science at this stage, following from the large amount of feminist work in this area.

Regarding the relationship between science and society, Nelson argues that, because science communities cannot be separated from the wider community, it is futile to think in terms of 'science of the future' or a 'successor science':

> If knowledge is of a piece, if it is the property of communities, and if special science communities are inextricably related to and embedded in the practices and beliefs of the larger society and political context, there will be no feminist society without feminist science. Feminist society and feminist science will evolve apiece, if at all (Nelson, 1990, p15).

Longino makes a similar argument when she argues that an oppositional science only becomes a successor science with changes in societies' values.

In the next section I will consider in more depth what Longino's and Nelson's theories of a feminist science mean for the practice of science.

4.5.3 Practice

Feminist empiricism takes the practice of science as its starting point. Both Longino and Nelson focus explicitly on scientific practice as opposed to scientific knowledge, and make the most detailed practical suggestions so far about how a feminist empiricist science might operate. Their emphasis on communicating with scientists is equally important. In many ways Longino and Nelson have succeeded in developing a practical framework for a feminist empiricism which avoids many of the problems of feminist standpoint theories and their postmodern hybrids. Their emphasis on a feminist science evolving from orthodox science, and in connection with changes in the wider society, is particularly pragmatic and so seems to avoid the utopianism of other positions.

Nevertheless I see three main points of contention within feminist empiricism which I explore further here. First I consider the status of the feminist scientist in the scientific community. Second, the controversy over evaluation of knowledge claims requires further examination. Should feminist scientists evaluate values embedded in scientific theories according to their acceptability in terms of the feminist communities' views, or should theories be subject to empirical testing? This addresses the earlier claim made by both Longino and Nelson regarding their transcendence of the dichotomy between objectivism and relativism. Third, I consider the disagreement between Longino and Nelson over theoretical pluralism or a commonality in scientific theories, which has implications for how a feminist science should be organised. The relationship between scientific subcommunities is the issue here, as is the extent of 'insulation' of different types of science.

Longino and Nelson are both clear that the epistemological unit should be the community of scientists, not the individual. I support their emphasis on the community and social location of individuals, given the way in which 'knowing' is a social process. However the role of the individual in the community is unclear. Individuals hold certain beliefs (which are shaped by the community), and espouse these views via points of reference and language acceptable in their community. Individuals are also capable of questioning and reconfiguring so-called 'community values' - feminist scientists have questioned the mainstream scientific community. Therefore, I would argue, there is at least some role for individual agency within a feminist science. This ties in with Nelson's point that there is no one feminist or one androcentric perspective, but a multitude. These are variations on a community theme, which can be ascribed to the individual. The relationship between the individual and the community in moving towards a feminist science therefore requires further consideration. It is important to understand how women come to join and remain within a feminist community of scientists.

The second, and perhaps most difficult, issue concerns the evaluation of knowledge claims with empirical techniques. Neither Nelson and Longino succeeds in confounding the alleged false dichotomy between objectivism and relativism. The tension is clearly between evaluating beliefs and values based on evidence or making a choice based on political commitment. Can all beliefs be evaluated on the basis of evidence? One problem is that the way in which evidence in selected, and combined, depends on one's implicit political and social commitments. Another problem is uncertainty: what one, at any one time, cannot know. As Longino in common with much of the sociology of science, in particular SSK, argues, to a large degree scientists find what they are looking for when they do science, since observation is theory laden. Even a type of science which sought to combine all the available evidence would be manifesting particular (political) values of eclecticism and fairness.

On the other hand, shouldn't scientists at least try to evaluate evidence based on empirical testing? I am uncomfortable with selecting 'feminist' values and deliberately embedding them in scientific knowledge. How does it get decided what values we embed in which science? In any particular subcommunity will there be consensus, or a variety of different science theories? If there is a variety will the subcommunities split, will science become atomised and incoherent? This relates to the first point which questions the extent of autonomy of individuals within communities.

The tension between objectivism and relativism remains. Longino also notes, in a point that is pertinent whether one advocates empirical evaluation or not, that it is difficult for scientists to 'see' values and beliefs in science, especially when they are comfortably a member of a particular community. She suggests scientists join together in examining and criticising science, using history and sociology, as do Keller and Harding. However, the mechanisms for promoting and learning such critical techniques in science are not discussed. As is the case with Harding's feminist science, the organisational changes required to support changes in methodology are not fully developed in Longino's theory of a feminist science.

Third, although there are obvious common links that all science shares in terms of ideology and practice, to qualify as a disciplinary subcommunity, a definitive topic or practice which is distinct from the wider community must be evident. To what extent to these definitive topics or practices make the knowledge produced substantively different? This has implications for the promotion of a feminist science. If certain sciences are more autonomous than others then change will be difficult to achieve through 'chain reaction'. There may be certain groups of scientific sub-communities where change might reverberate and others where it might not.

4.5.4 Conclusion

I argue that feminist empiricism is the most practical of the feminist science theories. The emphasis on practice, evolution, community, and values in science is refreshingly pragmatic. Nevertheless, whilst these theorists are 'closest' to feminist and women scientists, and aim to communicate with them directly, they still come from a philosophical background. Several tensions remain for putting a feminist science into practice: the role of the individual in the community; the relationship between different scientific subdisciplines and the potential for feminist science 'snowballing' through the disciplines; and finally, the mechanisms and criteria for evaluating values and beliefs that are part of the evidence in science.

4.6 Conclusion

The importance of theorising about a feminist science cannot be overemphasised. Feminists have long recognised the importance of providing an alternative vision of science in tandem with criticising the links between gender and orthodox science. They have made significant contributions to theory and epistemology. Standpoint theorists introduced gender into the Marxist equation of knowledge and social location. The postmodern critique introduces a recognition of difference in women's experiences and perspectives whilst retaining the goal of 'more true' knowledge. The third area of feminist empiricism follows in this tradition, in addition to recognising the need to think in terms of practical changes that can be made in moving towards a feminist science.

Nevertheless, in thinking about how a feminist science might be practiced I raised four main questions which, I argue, are not fully answered in the feminist epistemologies: who are the feminist scientists?; what is the methodology employed in a feminist science?; how is a feminist science to be organised?; and what is the relationship between change in science and change in society?

The tension between individual and community is the main theme, in my exploration of the status of feminist scientists. In relation to a feminist standpoint I asked to what extent is a standpoint achieved or rooted in experience, and, to what extent do women's experiences differ? This is also raised when considering situated knowledge and feminist empiricism: how much commonality do feminist scientists have, and how might this impact on their science?

The methodological questions raised in this chapter concern another fundamental tension in social science: between objectivism and relativism. To what extent can scientific knowledge be evaluated in relation to the standard of empirical evidence, ie 'closeness' to nature, or should political commitments be the criteria for evaluation? This relates to the above point: if political commitments are to be the criteria how coherent are they amongst the feminist community? Moreover, what is the potential for the development of systematic understanding of the way in which both micro and macro level political values shape scientific knowledge?

Both of these issues are closely tied to the organisation of science. I argue that insufficient consideration of organisational change is a fundamental weakness in the theories about a feminist science. I have previously argued that any realistic feminist science must develop from within science, in tandem with change in the wider society. This view is also expounded by feminist empiricists. Nevertheless it is unclear what the relationship between the social and the natural sciences would be in a feminist science? How would feminist scientists be trained? And, to what extent is there commonality between various scientific disciplines which allows for the 'reverberation of feminist change'? This last point is related to the extent of shared methodologies and common topics.

Finally, how would the public be involved in a feminist science, and what is the link between feminising science and feminising society?

In Chapter 5 I outline how I intend to explore these questions empirically, in order to suggest a ‘best version’ of a feminist science. As I stated in Chapter 1, my measures of ‘best’ are based on my commitment to a workable version of a feminist science which can be promoted from within the existing scientific institutions, that is one which links theory and practice. At the same time, practicality must not be at the expense of radicalism. The questions that remain concern the ‘best’ criteria for feminist scientists; the ‘best’ methodology or methodologies; the ‘best’ organisation and the ‘best’ relationship between changes in science and changes in society.

Chapter 5 Linking Theory and Practice

5.1 Introduction: Building a Practical Framework for a Feminist Science

The purpose of this thesis is to build a practical framework for a feminist science by grounding feminist theory in an understanding of the practice of science. There are three major aims:

1. The first is to develop a better understanding of how gender relations shape the practice of science by synthesising the feminist critique of science and women in science literature with the experiences and perspectives of current and past feminist practitioners of science, in addition to those of the next generation of scientists - today's science students. This will in turn provide a practical basis for change.
2. My second aim is to explore what a feminist science might look like by combining this first step in my analysis with the feminist epistemologies of science and the experiences and perspectives of feminist practitioners and students. This is with the intention of identifying the most practical version of a feminist science.
3. My third and final aim is to provide pointers to practical strategies for change. This follows on from the first two aims and concerns change in science education as well as wider changes to the organisation and practice of science.

I now draw out the implications of my review of the existing literature for these objectives, before moving on to introduce my empirical investigation.

5.2 Practical Considerations: the Position of Women in Science

In Chapter 2 I considered the issues for women in science, focusing mainly on the institutional inequalities surrounding women's employment in science. Of course inequality in the sexes' access to science starts much earlier than this: the message, both at home and in school, that science is a masculine pursuit also has a profound effect on limiting the number of girls going into the natural sciences at university (although the numbers are much higher in the life sciences than in the physical sciences). Once women have made it into the university system, success is by no means guaranteed. Discrimination and subtle discouragement are still evident. On graduating, women scientists can look forward to a career in science which is, in most cases, affected by sexism. In general, women scientists are in lower paid, lower prestige jobs in the 'softer sciences'. Women can be excluded from the networks in science which have important functions in distributing information and advice necessary for success in science. By the same token, women are ill-served by the paternalistic mentoring system in science. Furthermore, the lifestyle of scientists is difficult for many women scientists, especially the long hours expected of junior scientists. In a world where child care is still seen to be the preserve of women, child care facilities and flexible working arrangements are woefully inadequate. The competitive culture further alienates women. Such elements of the male domination of science mean that some women choose to leave science (if they are not 'pushed out' first). This is a self perpetuating cycle: the incidence of women leaving science further enhances the popular image of science as a masculine pursuit. This in turn limits the number of female 'role models' for girls considering science and puts many other women off a career in science.

These issues have been well covered in the women and science literature. The institutions of science are clearly sexist. This has major implications for any discussion of a feminist science, a fundamental feature of which must be an end to discrimination. However, science is also gendered - associated with masculinity - in a wider sense. This literature does not include a consideration of the social production of scientific knowledge and thus of how the research topics, aims, methodology, language, and discourse of science may be shaped by gender relations, nor does it address the gendered image of science. As discussed in Chapter 3, science concerning gender has a role in perpetuating gender ideology.

It seems likely that the relationship between science, masculinity and male domination is mutually reinforcing, but this is far from obvious and requires further consideration. The empirical part of this study addresses the following questions. How is the masculinity of science constructed? For example, are the male domination of networks of communication and mentoring related to a 'masculine style' of research practice? What about women in science? Do men and women do science differently, if so, in what ways? Does scientific training override particular gendered behaviour? Empirical information about how the practice and content of science is shaped by gender relations is needed to enhance our understanding of the gendering of science.

5.3 The Feminist Critique: Unanswered Questions

Chapter 3 reviewed the feminist critique of science in order to explore how science is masculine in practice. Three areas of concern came out of this literature: masculinity and theories of gender in general, the role of language, and the nature of scientific practice and knowledge. Starting with the first, there are clearly different masculinities in different social groups and men's masculine identity can change as they grow older. Following my empirical study I hope to answer the question: how, if masculinity is a social construct, do social relations in science reinforce scientists' masculinity and vice versa?

Language clearly plays a role in constructing both masculinity and practice. However, an overly deterministic view of language is unhelpful. I have shown, in the criticism of Lacanian psychoanalytic theories of gender, that masculinity is constructed through a complex interaction of social, psychological and biological processes. Linguistic links between masculinity and science may be used primarily as rhetorical devices, which begs questions about any literal associations. For example, is the 'myth' of objectivity more masculine than the practice? What do the associations in scientific discourse between masculinity and objectivity in the past, mean to the practice of science today? To what extent do scientists seek to control and dominate their subject matter and, by implication, nature?

The third area of concern arising from the feminist critique of science relates directly to the practice of science. Practice in science varies enormously - according to whether the science is observational or experimental, involved animate or inanimate 'objects' of study, is 'cutting edge', or mundane and repetitive. Moreover, the structures of scientific hierarchies limit the potential at the lower grades for input to new theories, or construction of new metaphors. It is only a small elite in science that perform such a role. The extent to which these various disciplinary approaches are gendered requires more detailed consideration.

A fourth area of concern that I have raised is the place of nature within scientific truth claims. Moreover, it is important for feminists to find some way of distinguishing between better and worse science, either depending on the acceptability of the values embedded in science, or its empirical accuracy, ie 'closeness' to nature.

5.4 Feminist Science: The Gap Between Theory and Practice

In Chapter 4 I considered feminist theories of science and introduced my analysis of the gap between theory and practice. I reject utopian aspects of the feminist science theories, in favour of a practical framework. This raises four main inter-related issues. First, the role of the individual feminist scientist within the feminist scientific community is highlighted. Are feminist scientists' and future feminist scientists' perspectives grounded in experience or are they achieved positions? To what extent do/will feminist scientists share views in common?

Second, the nature of a feminist methodology, especially the tension between relativism and objectivism, is an issue. The criteria for evaluating knowledge claims in science are yet to be established. Should these be based on empirical accuracy or congruence with political views in the feminist science community? This relates to the first area of concern - to what extent feminist scientists in the feminist science community share common views. The difficulty in fully uncovering how micro and macro political factors shape scientific knowledge is also at issue.

Third, the organisation of a feminist science is extremely important. I have argued that this is closely related to the number of feminist scientists and the potential for the operationalisation of a feminist science. How will the social and natural sciences be related and how will feminist scientists be trained? How much commonality is there between scientific disciplines? This will determine the extent of change in certain disciplines influencing others.

Finally, the relationship between science and society requires further consideration, in particular the role of the public in a feminist science, and the dependence of change in society on change in science, or vice versa.

5.5 From Theoretical to Empirical Questions

The next step is to develop empirical research, in an attempt to fill some of the gaps in the feminist literature, in order to identify a practical framework for the development of a feminist science. I chose to interview a wide variety of feminists working as scientists and as science critics (with science backgrounds) and a sample of science students.

Material from the interviews with science students provides a more conventional view of science, and pointers on what must be overcome in moving towards a feminist science (although this was not my original intention: see Chapter 6). I am interested in students' perceptions of how science is gendered, whether men and women do or know science differently, and, as a point of reference to this, the qualities that students think are important in science. I use this to build up an understanding of students' model of science. I highlight flaws and contradictions in students' perceptions based on: the radical science movements' critique of science and systems of domination and the role of ideology of/in science; the emphasis in SSK on the social construction of scientific knowledge; and the feminist critique of science as gendered. I also explore students' attitudes to feminism and to changing science, again to provide pointers to feminist educators and scientists hoping to promote a feminist science.

A secondary use for the student data is to criticise the feminist theories and epistemologies. Students' reflections on how science is masculine in practice, and ideas about how science might be changed provide insight into flaws in the feminist literature.

The questions I asked practitioners are in four main sections. First I am interested in *if and how science is experienced as masculine in practice*. How is science sexist and androcentric, in the widest possible sense and across different disciplines and different levels of research? I focus on all the areas of social relations in science, including communication amongst scientists, between scientists and students, research questions, methodology and analysis.

Second, I gather women's views *on whether men and women do and know science differently.* As I have previously argued, women sympathetic to feminism, and with an understanding of science from the point of view of practice, have a privileged perspective on the way gender affects science because of their 'outsider within' status (Collins, 1986). I try to build up a comprehensive understanding of the types of difference, again covering all the social relations in science, eg laboratory organisation, teaching methods, communication, and research methodology. This provides evidence and examples of how science is gendered in practice. Note that I am particularly concerned to explore the question raised in section 5.2 concerning how the male domination and masculinity of science interact in practice.

Third, I am interested in *how practitioners want science to change and how this fits in with the feminist epistemologies.* This produces detailed examples of ideas for different research projects, methodologies, social relations within science (eg lifestyle, networking, laboratory organisation), plus the role of scientists in society, and the way these interact.

Fourth, I asked questions about the *practicalities of different epistemologies, especially feminist empiricism and standpoint epistemologies.* What do respondents think of the role of the natural world in a feminist science? How would knowledge claims be evaluated, internally or externally; empirically or politically? How would consensus be achieved? The role of the individual scientists in relation to the science community; the possibility of a feminist science without a feminist society; the changes within science required to bring about a feminist science, eg more women in science; and differences in science training and funding, are all explored.

In short, I try to use this practitioner data to identify and 'fill in the gaps' in the feminist epistemologies of science. I evaluate the feminist epistemologies, identifying the pros and cons of each theory. This is combined with data from the student interviews, in addition to data covering how science is gendered in practice, to develop a practical framework for a feminist science.

Part 2 Empirical Exploration

Chapter 6 Empirical Research Design

6.1 Introduction

In this chapter I give details of my empirical research. I explain how I decided which subjects to interview, the questions I asked, and the relations between myself and the interviewees, and how this shaped the data. I then explain how I selected the data represented in Chapters 7 and 8, which I later analyse in Chapter 9.

6.2 Research Subjects

6.2.1 Students

When I started this thesis one of my initial research aims was to explore students' views on gender, feminism and science. I aimed to compare two groups of students: first, those with a knowledge of feminist theory from courses of epistemology; and second, those who had no formal knowledge. Each group was to be made up of male and female students from physics and biology to allow further comparisons based on the sex of the students and the science subject they were studying. I expected the first group to be more familiar with the issues, and to give more insight into how a feminist science might work. I hoped to provide evidence that teaching these kind of courses was one way to promote a feminist science.

I wrote to universities with a history and philosophy of science department to inquire about their courses for science students. I found one university - Leeds - which provided an options course for science students on history and philosophy of science (HPS) with a small section on feminist theory. I arranged to interview a selection of second year male and female students who had studied HPS and an equal number who had not, from zoology and physics.

In an effort to get a larger selection of views I aimed to supplement my student interviews at Leeds with interviews with students from Edinburgh University who were studying sociology of science, which also incorporated some discussion of the feminist issues by making an announcement at lectures, asking for volunteers.

6.2.2 Practitioners

To move towards a practical framework for a feminist science a detailed understanding of sympathetic scientists' views on gender and science and a feminist science is necessary. As I have already argued, feminist scientists and feminist critics of science who have a science background, or are 'close' to science more generally, are ideally located in the feminist community and science community. I argued this meant they could provide important insights into the feminist theories of science.[23] Of course there are different degrees of feminisms, ranging from the liberal equal opportunities feminists to the more radical feminists who see science as androcentric in terms of subject matter, methods and theories. I aimed to cover this range. A selection of disciplines and levels of experience was also important to gain a breadth of understanding of the different ways science could be gendered, and how a feminist science might be in practice.

I initially arranged interviews with feminists in the UK. I contacted feminist scientists whose names I was familiar with and also interviewed people that were recommended by these initial interviewees. I also advertised for interviewees in various women and science journals, and wrote to organisations for women in science. The numbers of women I interviewed at this stage were quite low, and typically liberal feminists. I decided to try to extend my interviews to feminists in the US. I arranged for a grant from the ESRC and contacted familiar names, as well as

[23] Note that I have covered the work of the six women critics of science whom I interviewed in Chapters 3 and 4, but I do not see this as a problem for the research design as much of the work covered is over ten years old, and the type of questions I asked specifically addressed the practice of science, whereas their critique was more theoretical.

advertising on a feminist bulletin board on e-mail. I also interviewed women recommended to me by previous interviewees.

6.3 Research Methods

6.3.1 Interview Schedule

Student Interviews

I arranged to conduct the student interviews between February and April of 1993. I constructed an interview script to cover the four main issues outlined in Chapter 5: experience of and perception of sexism and androcentrism in science; whether men and women do or know science differently; the qualities that should be important in science; and feminist science. Initially I developed a grid system, where respondents were to chose their response from a selection offered in a grid. After conducting two pilot interviews with colleges from a science background I decided to make the script less structured. I found that the grids limited instead of aided responses.

I therefore constructed a second schedule (See Appendix 1). On the first issue, sexism and androcentrism, after asking an open question about experience and views, I provided a list of aspects of science where bias may be involved, covering aims and objectives, research methodology and methods, and teaching. (See Appendix 2). I asked students to think about bias in each of these areas.

For the questions about sex difference in knowing and doing science I used material from Rosser (1990) which provided a list of suggested differences between men and women, eg women are more intuitive. I tried to ask the questions in a neutral way, for example, 'is either sex more patient?' (See Appendix 1 for a full list of questions).

I used a list, which I showed to students for them to select qualities that should be important in science. This included suggestions from Sørensen (1992), eg withstanding adversity, cooperation with others. I also added some qualities I knew to be associated with stereotypical notions of difference between men and women, eg patience (See Appendix 2).

Finally, in asking question about a feminist science I provided an outline for students of two main concepts in feminist epistemology: liberal feminist empiricism and feminist standpoint theory as explained by Sandra Harding (1986, 1991) (detailed in Appendix 2).

In addition, because I was aware of the problems with lack of familiarity with some of the terms and concepts I would be using, I arranged a pre-interview talk on some of the feminist science issues (see Appendix 3). I also provided a reference sheet with terminology and check-lists to prompt answers (detailed in Appendix 2). I had hoped to arrange a post-interview discussion session to see what happened when students of different views came together but this was not possible as students were unavailable at the time because it was the end of term.

Practitioner Interviews

I started interviewing practitioners with the same script as I used for the student interviews (see above). This proved to be over-simplistic for the more knowledgeable women I spoke to, so I adapted my questionnaire (see Appendix 4). I used the same format as student interviews with women who were less knowledgeable, and asked more direct and searching questions of women who were more familiar with the feminist theories and epistemologies of science (See Appendix 4). It is important to note that there was a lack of order in many of my interviews with feminist scientists, as the discussion tended to flow more naturally. I also asked particular questions of some women I spoke to, if I knew they had a special interest in, or a strong opinion on, one aspect of the feminist science literature. This makes the material more uneven than in the case of students, and it is therefore more difficult to compare answers directly. However, comparison is not the main aim of the analysis. The irregularity of the data also means that valuable input to certain questions from particular interviewees has also been obtained.

6.3.2 Interview Relations

In both sets of interviews I was concerned to have a good relationship with interviewees. I did not want to take a powerful role in relation to the people I interviewed, as it implied 'appropriating' their views and the possibility of misrepresentation. In the student interviews I wanted to avoid a 'tutor-student' relationship, where I would inhibit students from expressing particular views that they perceived to be the 'wrong' answers. I endeavoured to stress the equivocal nature of my views on many of the questions, especially those about women and men doing science differently. I did this in the pre-interview talk and in interviews where I felt students were taking this role. I also sent copies of the interview transcripts back to both students and practitioners and asked for feedback and comments.

However, the power-relationship between myself and the interviewees, was difficult to alter. My efforts to avoid the student-tutor relationship in student interviews had little effect. The very act of doing an interview, going away with the 'data', and analysing it, is privileging the interviewer's interpretation over the interviewees'. The interviewer is therefore in a more powerful position, semi-structured questions, feedback or not. Most students did treat me like a tutor. Some students obviously thought I was a failed physicist, and treated some of my questions with contempt ('what is the point in asking that?'). But most were polite and deferential. Some even apologised for not giving the 'right' answer. This was despite my strong assertions in the pre-interview briefing, and before the start of each interview, that I was equivocal on the issue of sex difference.

I did not have the same concerns about interviewing practitioners. Power relations existed nonetheless, and also affected the data I gathered. I am particularly interested in the way different women responded. The junior scientists, or women who are not very familiar with the feminist criticism were invariably extremely friendly and eager to give me 'good' answers (in this case, well thought through and complete). The more senior women, or well known participants in feminist criticism or feminist science, were also, in the main, friendly and very helpful. But their responses were qualitatively different. The interviews changed, in some cases I felt like I was being interviewed! Some women actively took control of the interview, usually in an attempt to fit it into a busy schedule. It is also interesting that these senior women, with some exceptions, tended to answer their phones during the interview, whilst the others did not. A lot of the questions could have been boring for them, as they had already thought them through and knew where they stood. Certainly many of their answers are very thorough, and well polished. As with the student interviews, I was not able to change these relationships. Ultimately, however, I am in the powerful position because I analyse the data.

6.4 Selection and Preliminary Analysis of Data

Student Data

The students interviews I used in my analysis are detailed below in Table 1.

The codes used in Chapter 7 are 5 digit, covering: sex (M or F); interviewee number; place of study (L=Leeds, E=Edinburgh); subject (Z=Zoology, P=Physics, B=Biology); and whether or not the interviewee had studied HPS (P=Philosophy, N=Non-philosophy).

Table 1

(L = Leeds, Zoology E = Edinburgh, Biology)

Zoology/Biology

	HPS	Not HPS
Male	2 L	2 L
Female	2 L, 2 E	2 L

Physics	Philosophy	Not Philosophy
Male	2 L	3 L
Female	3 L	2 L

It became quite obvious as I did more interviews that the HPS course had an extremely small component of feminist epistemology, which did not cover many of the issues I wanted to discuss. This part of the course was also poorly attended by students, and seemed to be treated with some amusement. There was no discernible difference between the views of students who had studied HPS and those that had not. There was also a lack of any significant depth of thinking about many of the epistemological issues I raised. The majority of students also failed to turn up to a post interview discussion session, largely because it was the end of term, so this was abandoned. I supplemented the student data with two interviews with female science students studying a course in science and society in Edinburgh, who had a similar level of knowledge and sophistication.

I chose to use the student data to provide a sketch of the conventional view held by students to illustrate what feminist educators must challenge. I also decided to look for inconsistencies in the conventional view that pointed the way to a more radical view of science. The data also threw up some interesting issues about the construction by feminists of science as masculine, which I also explore in my later analysis.

Practitioner Data

I succeeded in getting a good range of views and opinions from practitioners. In my analysis I use interviews with thirty women who all have science backgrounds and have either stayed in academia or retired, but are now variously involved in science as practitioners or, outside of science, as critics (one was conducted via e-mail). Three digit codes are used to represent the practitioners interviewed, covering: whether their principal role was as a critic or practitioner of science (P=practitioner, C=critic, PC=both); interviewee number; and broad subject area (B=Biology, C=Chemistry, P=Physics). These women's positions range from a liberal interest in promoting women and science through to a more radical criticism of science. Four main groups emerged from the data. The first accounts for roughly half of the women interviewed and is made up of women whose views are at the more liberal end of this spectrum. These women all have an interest in women in science, but not all would call themselves feminists. The majority are involved in groups to promote women in science eg: Edinburgh Women's Science Forum, set up to discuss women and science issues and arrange exhibitions and talks, which is now more of a support group for women in science; Zorra, a mentoring project for women physics undergraduates; and The Baltimore Charter for Women in Astronomy which mainly focuses on discriminatory practices in science. Note that some women in two of these groups were interviewed in a group rather than individually: this was organised by interviewees from the groups to save time.

The second group consists of six feminist scientists who are more familiar with the feminist critique of science, and to a lesser degree, the literature on feminist epistemology of science. A third group consists of three women who are part time scientists and also critics of science.

The fourth group is of seven women who have left research science for various reasons - disillusionment, exclusion by their peers or a greater interest in criticising science. These women are now teachers, onlookers and critics of science, usually outside of scientific departments in various disciplines, eg Education or Social Studies of Science. Their degree of involvement in criticising science varies: some simply follow the debates in feminist circles about science, whilst others are some of the key writers in the field.

I include five women from the UK in the first group and three others in the fourth group of critics. I include ten from the US (in all four groups) and twelve from Canada (mostly in the first group). This reflects the fact that the majority of active critical writers in this field are American. However, differences in the acceptability and style of feminism across the Atlantic are also apparent here: these can only really be noted without more detailed consideration.

Five of these women in the first group are still completing their doctorates, and two in the fourth group left science after their undergraduate degrees. However, by far the greatest majority of women that I spoke to (twenty five) have postdoctorate qualifications in natural science. Of these, eleven have permanent lecturing positions in science (referred to as having tenure in North America) and two are retired Professors of science.

The disciplines which these women come from can be roughly categorised into physics, chemistry and biology, with thirteen each in physics and biology and a much smaller four in chemistry. Of the physicists the vast majority, eleven, are in the first group of women scientists and the majority of biologists are split between groups two and four, whilst the chemists are spread more evenly across the four groups. This reflects a higher profile of women in physics as opposed to chemistry (presumably because physics is the 'harder' science and so has fewer women). The majority of critics in this area are also from biological science backgrounds as are the women who consider themselves feminist scientists. This also mirrors the difficulty in conceptualising and practicing a feminist physics.

6.5 Conclusion

I now give details of the interview material. First, I deal with the student data. This covers students' perceptions of how the sex of the scientist and gender relation affects science; their views on how science should change; and their attitude to feminism. The chapter is much shorter than the practitioner chapter because it mainly deals with a secondary objective of this study: exploring the teaching of a feminist science. The second chapter covers the practitioner interview data in more detail and is used to build a picture of how science is gendered in practice, and a better understanding of the process of feminising the practice of science in Chapter 9.

Chapter 7 Student Interviews

7.1 Introduction

In this chapter I document students' perspectives on science, gender and feminism. My aim is to lay the ground for the later analysis which relates feminist critiques and epistemologies of science to the practice of science. As detailed in Chapter 6, I originally intended to examine any sex or subject difference in student responses. I also hoped to consider differences in the views of students who had studied philosophy and those who had not. However, I found that no such differences were significant in shaping student responses in the majority of instances, with one notable exception, which will be considered in the later analysis.

I start in section 7.2 by detailing students' perceptions of gender and science, including their experiences and attitudes to sexism and androcentrism in science; whether men and women do science differently; and their perception of what qualities go together to constitute 'good' practice in science. In the next section, 7.3, I consider their views on changing science, addressing sexism, androcentrism and their reactions to feminism and science.

7.2 Student's Perception of Gender and Science

7.2.1 Sexism in Science[24]

There was a recognition of sexism in science amongst most of the students whom I interviewed; 8 out of 10 women had experienced sexism, most commonly via teacher's sexist assumptions. There was also a strong perception that this type of sexism did not affect the content of science. A significant minority also argue that the

[24] Note: the students I spoke to had a limited experience of science. This means some felt unable to answer questions on sexism in research, and some referred to sexism through knowledge from reading, not experience. Similarly, 6 pointed out that questions on funding were beyond their scope.

male domination of science does not necessarily equate with sexism. For example, one woman commented,

> I haven't actually seen many things published by women in science, I don't know whether that's because there aren't as many women publishing things ... in the biological sciences, yes ... that must be a generation gap. (F2LPN)

This corresponds with a general naiveté about the position of women in science and how to improve it, which will be considered further in section 7.3.1.

7.2.1 Gender and science

I was particularly concerned to establish whether the students I spoke to had experienced or perceived science as androcentric and/or masculine. Did they view androcentrism and masculinity as being confined to external areas of science, or as playing a role in the practice of science? More specifically, did they view reductionism and objectivity as masculine?

The majority of students rejected the notion of androcentric or masculine influence on the methods of science. For example,

> I don't think [science is androcentric] because when you were saying before about how men would just look at one variable and study it and a woman might look at the overall picture as far as I'm concerned we do the opposite, because you can't really perform an experiment, in physics anyway, trying to look at the overall picture, it just won't work, you have to have each thing individually and then put them together. As far as I'm concerned experiments are ... asexual. (F2LPN)

This student argued that physics demands a reductionist approach from scientists, male or female, and that this is asexual. Perhaps her rejection is related to an interpretation of the suggestion that females were more holistic as saying females were less competent at physics. The importance of the rigidity of scientific training is highlighted here, and will be considered later.

There was an openness on the part of most students to the idea of science as androcentric (14 out of 19). The most articulate response was the following:

> We had this tutorial the other week with a bloke ... his specialisation is contraception ... control of population ... he was talking about this thing called Norplant which is 5 match stick things which you stick in your arm and it protects you 97% against pregnancy, it's for use in the third world. We had this big argument ... he was talking about how we should just leave the third world alone, we shouldn't feed them or anything because ... looking at it from a biologist's point of view ... this is a natural thing that would happen in biology - disease and famine come along, knock down the population, let the resources build up ... and he said the root of all the problem ... with over-population was that these days if a single woman gets pregnant we don't throw her out in the streets, we give her welfare ... and ... the pill ... it's giving everybody this freedom, but it's not completely effective so the population is running wild. That blew us up when he said that. (F5LZP)

This student viewed her tutor's opinions as male centred because of his (somewhat contradictory) morality, which condemns women who have children out of wedlock, and women who were sexually active without using effective contraception. This student continued the theme of masculine influence in science, in a response to a later question about whether science is masculine:

> I do [think science is masculine] in the fact that it's always been regarded as a male dominated career ... the men have got time to sit and think whereas the women haven't because they've got other things to do ... in that case the men have got time to grow up to be scientists ... and so its always been seen as a male dominated area, but ... I think that, say ... lots of male Doctors ... if they can give you the pill that will stop your leg dropping off then they will ... but it seems that nurses or female Doctors ... will follow up, see how you feel ... that's just the different nature of men and women ... The men are definitely more practical ... in that they have closed vision to anything else, to morals and things that might be behind things, and I think ... with war and weapons ... they're all into that, whereas if men had period pains they'd be sorted ... instantly. (F5LZP)

This response has several important features. First, this student related the pursuit of science to men as she saw science as a creative luxury that men can indulge in, whilst she saw women as having less opportunity for such a pursuit because of more pressing responsibilities. This is presumably related to the different social roles of men and women. The second point of interest here was the student's comments about females in medical science being more empathetic. It is also worth noting here that this student took an essentialist position - arguing that men and women have different natures implies that there is something inherent about masculinity and femininity. Third, she suggested men were more practical and their work reflects their own interests and a relative lack of interest in women's problems, eg period pains.

The rest of the students' responses were less definite about science being androcentric. Consider, for example, this student's answer to the question about his experience or witnessing of androcentrism.

> I think maybe quite a lot of the literature you use may tend to be written by men, but they're not written for men particularly. (M7LZP)

Now compare this with his response to a later question on the methods of science being masculine:

> I think a lot of methods in science ... because there are so many men in science, are male ideas, but I can't see how if they had come from females they would have changed drastically. (M7LZP)

There is a difference between the student's view of science as being performed by men, but not being influenced in its goals because of this (ie science is done by men but not for men), reflected in the first quote, and the perception of scientific methods as maybe being influenced by men's ideas in the second quote. The contradiction lies in confusion about the way in which masculine attributes actually affect science.

The majority argued that the scientific methods are not androcentric. This woman commented:

> I think the act of doing science would be the same either way, but that the way it's directed is very masculine, because much more emphasis is placed on

> economic importance, you're going to have ... military research ... and that's all come from a masculine bias in politics ... the directives of science are masculine, I don't think the methods of going about it are. (F7LZN)

This student drew a distinction between the application of science (which are shaped by men's interests) and the methods, which are gender-free.

There was no consensus amongst the students I interviewed about the extent and nature of men's influence on science. In particular the way in which the male domination of science is related to masculinity and the notion of a male world view, or essential male qualities affecting science, was ambiguous, as was the relationship between the aims and methods of science and the wider issues of funding. Rather than simply viewing this confusion as an indication of the limitations in students' thinking, it may be more useful to see it as an indication of limitations in the feminist critique of science as gendered. This will be discussed further in Chapter 9.

Although they were a small group, those who argued that science as a whole were androcentric, were all male bar one. On the other hand, those who argued that some aspects of science were androcentric, but that the methods were neutral, were all female bar one. This suggests that males were more amenable to the idea that science is androcentric in a wider sense, and women were more concerned to stress that the methods of science were neutral. A possible reason for women's hostility to the notion that science, particularly the scientific methods, are androcentric was their equation of the argument that scientific methods were gendered with the argument that women were less suited to science. This is also related to two women's argument that to say that sexism could infiltrate the methods of science, because men and women do science differently, was itself sexist. This idea is much more prevalent in the next section where it becomes clear that students rejected the idea of men and women doing science differently because they saw such a distinction as sexist.

7.2.3 Sex and Doing Science Differently[25]

The methods of science were seen by the majority of students as neutral, and acting to suppress any prominent differences between individual's results. The differences in scientists' practice that were identified were mostly related to individual personality, not sex. Consider the following example of this general theme:

> Again, I think it depends on the person ... but in science I think the emphasis is on a reductionist approach, because again, you can't solve a problem if you concentrate on a lot of things, you have to isolate something. (F9LZP)
>
> What about being objective? (AK)
>
> No one is objective ... I mean you can use objective methods but you really explain something as you expect it to be, it comes from your personality your experiences. (F9LZP)
>
> So you don't think men or women are more objective? (AK)
>
> No one is objective. (F9LZP)

Roughly half of students - 10 out of 19 - viewed scientist's influence on their work as being related to their individuality, which was not seen to be related to their sex.

However, some sex differences in scientists' practices were identified. A significant minority argued that women are more patient (7 out of 19), or more concerned with detail and more self critical (6 out of 19). For example:

> Ah, now you're talking [about a difference in observation] ... well this is a strange one ... generally I'd say that the girls are a lot more patient than I am because if an experiment doesn't work I lose my temper within an hour ... some of the girls I work with ... go on. (M9LZN)

---

[25] It is important to note that a significant proportion of the students (7 out of 19) commented at some point in the interview that the methods of science they use were laid down in guidelines for how to approach practical work in the teaching laboratories, hence the opportunity available to them to choose particular methods was limited.

> I think the girls tend to be more critical ... and say, 'we could have done this, we could have done that', whereas the boys think it's been and done. (M7LZP)

This fits in with a view, held by the majority of students, of science as being gender neutral and objective, and with the minority view of science, where students argued that it was not possible to be objective. Patience and criticism were not related to objectivity:

> That's the thing about science, that's why I like it because its either right or wrong, the way I see it anyway, it's not as complicated, so ... the level of hormone goes up or it doesn't ... so there's not that much subjectivity comes in (F5LZP)

> They [men and women] both can be equally objective, or depending on what data you've got, what you've read, they can be equally subjective ... or even who's taught us what ... they've got a certain leaning towards a certain idea, a hypothesis, and they've taught it to us, then I suppose we're all equally subjective (M7LZP)

A significant minority - 8 out of 19 - also argued that men were more likely to be scientists first and foremost in their lives:

> I'd say that was a man's point of view [being a scientist first and foremost] - he is a scientist whereas a woman has other things, like if she's going to have a family and that sort of thing, it all has to be interactive in her whole life. (F7LZN)

The same proportion thought men were more interested in control of nature:

> I think males tend to think they're trying to harness nature, to use science to turn nature to their advantage, perhaps females think they're trying to work with nature ... looking at science as a way forward ... I think males are definitely more towards controlling nature because ... you're depending on industries such a lot who're funding science ... the top level industry tend to be male dominated ... I think men definitely want to be able to turn nature to their advantage. (M7LZP)

Women were seen as more empathetic by a similar number of students:

> Yes. Well, I don't tend to get involved in anything. OK we have rabbits ... I'd be quite happy to kill any of them. (M6LZN)
>
> What about the girls? (AK)
>
> I don't think so. (M6LZN)
>
> Do they empathise more? (AK)
>
> Yes, definitely, not with the creepy crawlies. (M6LZN)

And from a female point of view:

> The lads have got this bravado act - 'yes, we'll chop the head off the locust' - where the girls are more reluctant ... to do so ... I don't think its because they're worried about hurting them but simply because it's not necessary half the time - not everyone has to cut the locust but you can if you want to - the lads will go on ahead and do it. (F5LZP)
>
> I think that's the girls [who are empathetic]. We occasionally do something with frogs and boys are pulling their legs off - stupid things like that - girls wouldn't do that ... they see it from other people's point of view. (F10LZN)

The emphasis in each of these cases - men's role as scientists first and foremost, women's empathy and men's control of nature - was on females' viewpoint being different from males', and can be related to women's role in the private (and emotional) sphere as opposed to the public (and rational) sphere. However, this is contrasted by a general emphasis on there being no differences in the 'core' practice of science, from choice of experiment to interpretation of results.

Neither sets of differences identified by students - concerning patience and self criticism or empathy and control - compromised their views on scientific theories and data as not being open to influence by the sex of the scientist. I would argue that this is an important conclusion for students. Consider this statement from a female physicist:

> They're both about the same [men and women]. I suppose it's always thought of that it's a man that should be the one that's controlling nature but if women come into science they want to control it just as much as men do. (F4LPP)

Controlling nature was associated with men, but women were also seen as being able to adopt these values when they come into science. I view this as related to the nature of scientific training and ways in which it may suppress difference between men and women. More importantly, as argued earlier, this conclusion is important for female students, as it means no one can argue that because they do science differently they must be doing science badly. Perhaps the focus on women's patience and self criticism; men's perception of their role as scientists as first and foremost in their life; women's empathy; and men's association with control of nature, is especially easy for females (and males) concerned about the implication of their identification of difference (ie sexism) because they find it easy to dissociate these factors from scientific methods and results. Although students accepted that control and empathy might guide the aims of some science, and that patience and self criticism might affect the time it takes for results to be uncovered, theirs is a view based on their experience in learning science by repeating old experiments where the results are already 'known', so they find it easier to accept that scientific methods and results are untainted by these factors. On the other hand, these features clearly do affect the content of science. Surely, in a less restricted environment where new science is being done (as opposed to repetition of old experiments as in the teaching lab) patience and self criticism will affect the quality and type of results. This will be explored later in Chapter 8.

7.2.4 Good Science

In this section I consider the qualities that students thought were important in science and how they relate to gender. This is based on a set of questions in the interview where students were asked to select from a list the qualities that they thought should, and should not, be important in their ideal science. In practice, however, probably because of the way that students have been taught science, this question seems to have been misunderstood. As science teaching provides standardised and uncritical versions of methodology, some students seemed to respond instead with qualities that they have learned were important in science. Nevertheless the information obtained is still valid to a degree, as it provides a snapshot of what students thought good science meant.

The majority of students identified the following qualities as important: objectivity; working in a group; working alone; creativity; intuition; inventiveness; patience; accuracy; cooperation; and questioning information and theories. Engagement in social and political issues were identified by the majority as not important. A significant minority (between 6 and 8 out of 19) also considered respect for nature; practical sense; empathy; and ability to withstand adversity, to be important. Interestingly, there was no clear differentiation between supposedly opposing values. Most importantly, both subjectivity and objectivity were identified by 6 students as important. For example:

> Yes [objectivity is important]. There's no point otherwise, is there? It's important to be able to work in a group, though, because otherwise there's no point, you've got to consider other people's opinions, or you're just going to be wrong ... you need to be able to take other people's opinions [into account]. (F1LPP)

> I think there's a place for both [objectivity and subjectivity] ... because you need to be able to see things, and sometimes you need to be able to see them clearly, but sometimes you need to be able to look at them in a different direction ... you have to be subjective as well as objective, you have to get a balance. (F4LPP)

The general theme was the importance of recognising subjectivities - via group interaction in the first case, or looking at your results from a different perspective in the second - and how they affect science and then trying to eliminate them.

Others argued for both respecting and controlling nature:

> It depends on the experiment you do [whether you are respecting or controlling nature] ... apart from the obvious, like nuclear physics which would affect nature, most physics is of use to nature and is not necessarily detrimental to it in any way. (F2LPN)

This highlights the problem with generalising about control or respect of nature, and what they actually mean in practice. Note that control and respect are not necessarily mutually exclusive.

A significant minority also argued that both reductionist and holistic models should be used in science, depending on the experiment.

> I think in physics ... breaking things down into constituent parts [is important] ... until electricity and magnetism unified ... they were two separate areas - you look at an area then investigate it and then you come up with a few theories and then, maybe later on, when you've got those theories you can ... group them together ... I think it's necessary, if you're going to make progress, to break the problem into constituent parts and then tackle it rather than tackling the whole thing, it might just be too complicated, too overwhelming. (M4LPN)

This student illustrates the way in which holism and reductionism in science are interdependent, and how the two must interact in the interests of 'progress'. Although this betrays a naiveté about scientific progress depending on adding together the constituent parts of knowledge to come up with the whole answer, an important point is being made - reductionist scientific research design plays an important part in science, asking questions which are not so large as to be impossible to answer.

Whilst the model that emerges in this section clearly has an empiricist emphasis because of its stress on objectivity, there were other qualities which students considered to be important which have no place in a positivist empiricist science, for example intuition. Similarly, from this information it is impossible to construct any clearly androcentric or feminine model of science, as both supposedly masculine and feminine qualities were mixed together. What I would identify as the major features of an androcentric model of science - objectivity; control of nature and reductionist models of the dominant constituent variable - and of feminine science - inclusion of subjectivities and context in research; respect for nature's complexities; and complex interactive models of a more holistic style - were intermingled.

Furthermore, the model that emerges is full of contradictions and ambivalence, which, I would argue, represent to a degree the conflicts and ambiguities that the work of the scientist involves. These include respect for and control of nature - it is by no means clear from the data what these actually mean in practice. The elusiveness of the goal of objectivity is also apparent in students' experiences and perceptions of science; this is hampered by the biases and subjectivities which scientists hold but cannot necessarily define. The methods scientists use are also difficult to categorise based on the data; the two approaches of holism and reductionism were seen as complementary rather that diametrically opposed.

7.2.5 Conclusion

Students viewed the influence of sex and gender on science as relatively insignificant. Although there was an awareness of sexism, this was seen as unimportant in shaping the content of scientific knowledge. Equally, although the majority identified differences between men and women in science this was seen as not influencing scientific knowledge. A minority did accept that science might be gendered, but there was confusion about what this meant (whether it was in terms of male domination, male world view, or essential male qualities) and how it affected science.

In general an empiricist epistemology of science was favoured by students, reflecting their training and education. Nevertheless there were some notable contradictions: eg some students' emphasis on objectivity and subjectivity, and reductionism and holism as being important in good science. Therefore students' ideal science cannot be labelled 'masculine' or 'feminine' (according to feminist categories discussed in Chapter 3).

The final interesting result is the greater openness of male students to the notion of science as masculine. Women students, I suggest, have more to lose from labelling science masculine, as they were already under confident about their position in science.

7.3 Changing Science

7.3.1 Solutions to Sexism

In this section I consider student views on how to challenge bias and sexism in science. Here the predominant view was fairly liberal: students advocated getting more women into science to add 'balance' via peer review, but also displayed a general faith in the scientific method as able to eliminate any extreme biases. There was a general optimism about increasing numbers of women in science. Sexist theories in science were viewed as rare and therefore easily dismissed.

For example:

> I think [bias is] unavoidable, but you have to be in a position to overcome that bias ... in a way I see it as like some sort of verbal tennis ... you're always going to have two biases, a man's bias and a woman's bias, but if you're allowed to work together in equal numbers that would maybe come to some sort of happy medium. (F7LZN)

Although bias was seen as unavoidable (science is therefore seen as subjective) there is an implication in this quote that some biases are better than others - the 'happy medium - being a 'balance' between men's bias and women's bias. At present, therefore, science is seen as biased too far in men's interests, and as more women enter, things will even out.

The next quote illustrates a commonly held view, promoted by the way science is taught, that the passing of time helps to achieve objective results as new generations of scientists review old theories and eliminate biased ones. This was in response to a question in the interview which gave an example of a 'sexist scientist'. The students were asked if there was a scientist with sexist views on men and women who was studying the difference between men's and women's intelligence, but was a very thorough scientist who used objective methods, would his results be sexist? Consider the following response:

> Just going on past experience, similar things back in the late 19th Century ... where white people were trying to prove that white people were cleverer than black people ... and whatever methods they used ... whichever group they were from, they always ended up that the group that they belonged to was the best, at the peak, at the top of the evolutionary tree, and more enlightened scholars have found that it was a load of toss ... I'm sure if somebody was doing something along those same lines now he'd fall into the same trap and prove his ideas, at whatever cost, maybe mislead into, but he'd probably believe he was correct and producing something that was tangible and provable, but within a few years someone else would say, 'that's a load of rubbish' ... If the experimenter has a strong enough view then he's always going to prove his view if he's doing an experiment like that [sexist scientist example] and if he doesn't prove it he isn't going to publish it. (M9LZN)
>
> OK. How do you think you might combat that? Do you think more women in science would help, more science peers who were women ... or black...? (AK)
>
> Yes ... in a perfect society there would be 50:50 ... but there aren't ... but in 10, 15 years time when these levels are at equilibrium it'll be much better then. (M9LZN)

The solution this student advocated is two fold - 'balanced' peer review which will be achieved through increasing the numbers of women in science, and the passing of time which will eliminate biased theories and mean that more women will go into science.

The general optimism about the impact of more women on science is illustrated in the following quote:

I think it'll eliminate sexism in people who aren't scientists because they'll see that more women are going into science, so that's good, whereas the scientists that are already there - the male scientists - I think you will still have to work a whole lot harder to get the same respect from them as they would give their fellow males ... (F5LZP)

What about the theories ... the ideas? (AK)

Definitely the more theories that women can put forward then the more respect they should gain ... and hopefully, the more women that there are ... eventually people won't look at scientists and see ... more men than there are women. (F5LZP)

This is a clear argument for more women in science as they encourage other women through example. Others had more confidence in the scientific method. Consider the following discussion about sociobiology:

I really don't think that [sexist bias] exists, actually, in most science that I know ... in fact it can be proven that, ... whether it's a man or a woman that finds it out, it's just there, you can say it's one of the laws of nature, it's got to happen. [sexist scientist example] Yes, I think that if he's a true scientist and he's really trying, I presume that he would be if he's doing research, you do try and separate yourself from the experiment, you wouldn't try and influence it in any way, especially with biological experiments ... psychological experiments as well ... you can influence the subject a hell of a lot, if he's trying to do it properly he will try and remove himself from the experiment ... and maybe have some sort of control that he can apply. (F2LPN)

This quote illustrates a faith in the scientific method and individual scientists' ability to eliminate their biases through application of scientific methods, such as the use of control groups. There is also an appeal to the 'integrity' of scientists, who are seen as unlikely to compromise their work with their biases.

Three students in this group also distinguished physics from biology in their response to the sexist scientist example:

Well it depends on his facts. I'm slightly different... I'm doing physics ... acceleration doesn't matter whether you're a man or a woman doing it, so it

> doesn't really apply to me ... if he's a good scientist and he looks at the facts ... he shouldn't come out with [bias]. (F1LPP)

Here students were arguing that it is easier to be objective in physics because physics deals with inanimate objects. Others displayed even more faith in the rigour of the scientific method:

> Do you think more women in science is a good idea? (AK)

> Yes, if they want to, but I don't think ... I'm not one of these people who says, 'Oh look, there's more men, we should let more women in, or make more women do it', if they don't want to do it they shouldn't. (F10LZN)

> I think more women is definitely a good idea, because it's a male dominated field at the moment and there's no reason why it should be. (M6LZN)

> Do you think it would make the science better? (AK)

> Well science will get better anyway, no matter who does it. It'll just make it less male dominated and in that way ... in the future when women start coming through as professors and lecturers, it might encourage more women into science. (M6LZN)

This student was referring to the progress of scientific knowledge, ie new generations of scientists disproving old theories and replacing them with newer and better theories. All of these students were advocating the status quo of traditional science.

The implications of the student's naiveté about the progress of women in science and/or the rigour of the scientific method will be explored further later.

7.3.2 Solutions to Androcentrism

Students' openness to androcentrism and masculine influence in science, illustrated in section 7.2.2, did not extend to the idea of a feminine method of doing science as a valid alternative - only one student accepted that there might be such a thing. The overwhelming majority - 16 out of 19 - were against the idea completely and argued that scientific methods should be neutral, not masculine or feminine. For example, as above, one student's solution to 'masculine bias' was to keep science as it is and try to be more objective.

> Changing the ways of science ... it's distinguishing again between the groups [men and women] which maybe isn't a good thing ... maybe it should be kept to what it is and obviously the bias removed. (M4LPN)

Another student described how science should be neutral:

> If you can think of a particular feminine method I think you might find that men are a bit adverse, and vice versa. If you say this is a masculine way of doing things and this is a feminine way, then surely that's no better ... [it should be] neutral, yes. (M6LZN)

The main emphasis in all of these students' responses was on neutrality, a gender-free science. This has much in common with feminist empiricist aims, and will be discussed further later.

7.3.3 Reactions to a Feminist Science

In this section I consider student's views on the meaning and nature of feminist science. First, I deal with their initial thoughts on what a feminist science might be, and then I continue to look in more detail at their second response, based on a written description presented as a reference sheet and including a brief description of two main ideas about a feminist science - Harding's liberal version of feminist empiricism and her general description of feminist standpoint theory (see Appendix 2).

Students' initial view of a feminist science was, in the main, negative (11 out of 19). A small group of students said that they couldn't imagine what a feminist science might be (4 out of 19), and another group of 4 responded quite favourably to the idea, although none were clear about what a feminist science meant and gave vague answers, for example, that a feminist science might be more caring.

The negative view consisted of two main strands: the first was that feminist science was the opposite extreme from masculine science, and that what was needed was a balanced approach:

> [Feminist science makes me think of] militancy ... if you're going to have feminist science then you must have masculine science as well, you can't have two halves and not make them whole, its not possible, science should be neutral, it shouldn't be masculine or feminine ... people shouldn't try and separate it. (F2LPN)

> I can't see what difference a feminist science could be from ... what's the male version of feminism? ... If you look at a lot of feminist writing it seems to be [that] they're not trying to promote an equality of opportunity ... which is what should be the case ... They're trying to promote reasons why one should be better than the other ... people refer to it as positive discrimination ... I don't think there's any positiveness about it ... I presume that a feminist science would be pretty much the same approach to science ... Feminist science is only if it's conducted in ... a non intrusive way, only allowed to be studied by women ... and only women's papers can be published ... Science should be a separate thing ... should be above, or below, depending on which way you look at it, all these things. (M1LPP)

Here feminist and feminine were collapsed together, as were androcentrism and masculine, and set as opposites with neutrality the happy medium.

A second group of students were against feminism for similar reasons, but focus more on the characteristics of the comic book feminist:

> I think it would be your raving feminists ... when you stand on the outside of things screaming at people it gets you nowhere ... you turn men against you .. you all have to be allies ... so if you have a feminist science then you're going to have all the other areas that women are trying to get into against you ... what it actually would be I don't know. (F7LZN)

> Do you think of a feminist science as feminine; do you think men could participate? (AK)

> I don't think it would be ... mainly because ... again you jump to assumptions, generalisations, a feminist is someone who stands with cropped hair ... ears pierced ... and you immediately think ... a masculine image, which is wrong ... I suppose I'm a feminist but I don't go round telling all men what's what and, 'I'm right and superior to you', because that's just doing exactly what a man is doing . (F7LZN)

The themes of balance also comes out here, and is mixed with a view of feminists as unbalanced by anger.

Interestingly these initial views were followed by more detailed responses to the two feminist approaches which did not involve a total rejection of feminism. There were five groups of response to the two feminist versions of science. One of the largest groups (6) favoured a mixture of a feminist standpoint and Harding's version of a feminist empiricist approach, whilst a smaller groups (3) favoured a weak version of feminist standpoint. Another larger group (6) favoured an empiricist approach, which has little or no feminist input and only 2 favoured a stronger feminist empiricist approach. There were 2 other students who favoured both a mixture of the feminist standpoint and empiricist approaches, but also favoured a 'neutral' approach.

Consider the following example:

> I'm just thinking about the top one [feminist empiricism], feminists should be able to eliminate the bias [and] should become more involved in science ... to police ... so in other words ... more women ... yes I agree ... but I do think that society [doesn't] really encourage you in general. I don't think it's the schools, I think it's the general thinking in society, and I've no idea how you change that. (F1LPP)

On feminist standpoint theory she continued:

> I don't understand what they mean, what anyone means by a feminist standpoint ... then again I do consider science as physics, so I do consider it as being values and equations. (F1LPP)

I suppose it would mean, being a feminist and taking your values into the science that you do. (AK)

Well I don't you see, I consider it completely separate ... if you do that then there is going to be a bias ... and that's going to affect your science ... it wouldn't be a fact . (F1LPP)

They take the view that all science is biased anyway. (AK)

True, yes ... so they say that we see science better, because we're not the dominant group ... I don't agree with that at all, we're all the same, everyone should be the same. (F1LPP)

This student was clearly expressing a feminist empiricist view, which was in opposition to feminist standpoint theory. The second student used similar arguments, but also argued that more women in science was good and that both men and women should 'police' science, with neither having a better vision of reality:

One thing we're always getting hammered into us in lectures is that you've got to ignore your own position in science. When you're looking for a theory its got to be universal: any other observer on the other side of the world should be able to see the same ... no one can have a better vision of reality. (M5LPN)

Again, quite how one effectively 'ignores' one's position in science was not explained.

The fundamental difference with the rest of the students' views was that the concept of an unbiased position is seen as more problematic. However, as we shall see, there was no radical departure from an empiricist philosophy. These students still argued that an objective stance, no matter how difficult, should be the ultimate goal of the scientist.

Those that advocated a mixture of both Harding's version of feminist empiricism and standpoint theory tended to take the same position: knowledge is grounded by the standpoint of the knower, but one must seek to eliminate that grounding, and aim for an objective truth; neither sex has a better vision of reality - everyone's vision is different and equal; and more women should become involved in science. However, there was disagreement about whether it was necessary for women to police for sexist bias or for the scientific method to be more rigorous.

Consider the following view. This student has already studied feminist epistemology, and originally gave a negative interpretation of feminist science as it was the opposite extreme from a masculine science:

> I can see how one of the approaches, the liberal view ... would work, but it wasn't strong enough, because if all the claims were true just advertising for more women, and [having] more models for women in science [would have worked, but] it's not going to work. But then I thought the radical view was too radical. It was as if it was man hating ... it was, 'science is completely male dominated, science is a male way of thinking, is created by males, so it must be male orientated' ... it was very ... anti- male. (F4LPP)
>
> So what do you suggest, something in between? (AK)
>
> Well, we definitely need the role models and all that stuff ... but we have to change the view ... you can't hate men, you've got to work with them, otherwise you can't work as a group ... you've got to get rid of the inferiority that women have [about] being scientists. (F4LPP)

On feminist standpoint theory she continued:

> I agree with the first bit, that all knowledge is grounded by the standpoint of the knower ... I don't agree with this, that, 'women's position as the oppressed gives them a better vision of reality,' it's not oppression ... if you're removed then you can see something much better, rather than if you're in the middle of what's happening, and I think that could happen with a man or a woman. (F4LPP)

This student rejected the notion that women have a privileged standpoint, and argued that being 'objective' in the sense of separating oneself from the object of study provides a better vision of reality. Again, the concept of balance also emerged from this students discussion of feminist standpoint theory:

> But the feminist scientists should do science from a feminist standpoint, that's not going to be right ... because then you're still going to have bias ... then you just get the opposite of a male centred science. (F4LPP)

So, there is a mixture of views of feminist standpoint theory and empiricism here: the student seems to be saying all knowledge is grounded but one should strive to find an unbiased, neutral position (as mentioned earlier), through distancing oneself from the subject. Empiricism is viewed as not strong enough and there is the feeling that more should be done to encourage women into science, but feminist standpoint theory needs to be more 'men-friendly'.

7.3.4 Conclusion

The majority of students I interviewed displayed a faith in the ability of the present scientific methods to eliminate 'bias'. They were also optimistic about getting more women into science and, in general, saw this as a positive goal. Their rejection of a feminine method and a feminist science was based on the principle of balance and neutrality: feminine/feminism was seen as the opposite 'extreme' from masculine or masculinist science. The minority who were more skeptical about the notion of objectivity, nevertheless wished to see it retained as the ultimate goal of science, and countenanced a more thorough exploration of subjectivities in order to aim for such a goal.

7.4 Conclusion

Students' views on science, sex, gender and feminism will be analysed in Chapter 9. The most popular perspective was of a neutral and asexual science which could be improved by more rigorous application of traditional scientific methods. Although sexism was recognised it was seen as separate from the content of science. Women were said to do some things differently, but these were separate from scientific knowledge. The concept of equality between men and women was also important, leading students to advocate more women in science, and to dismiss suggestions that science was gendered as sexism. It is especially interesting that it was women who were more concerned to stress a lack of gendering of science.

A minority did make some connections between gender and science, but were vague about the nature of any links. Students did not adopt the feminist labels of masculinity and femininity on certain qualities in science. Moreover, certain supposedly oppositional qualities which were associated with masculinity and femininity in the feminist literature were named as important in science by students, and viewed as complementary.

Students' perspectives on changing science reflected these views. Most favoured a continuation of the present approach in science and stressed balance between male and female, masculinity and femininity. Even those who were more skeptical about the notion of objectivity being able to provide true, unbiased results, wished to retain it as the ultimate goal of good science.

Chapter 8 Practitioner Interviews

8.1 Introduction

This chapter is split into six main sections. The length of each reflects the richness of the data, and is necessary to illustrate the inevitably complex and apparently contradictory elements of practitioners' responses. In section 8.2 I consider social relations in the scientific community. I also look briefly at social relations between the scientific and wider communities. This deals with issues that arose in relation to women's experiences of both informal (eg networking) and formal (eg employment hierarchy) social relations. In section 8.3 I look more at the research practice of science, in particular at the topics that scientists study and their methods of study.

The main approach in these sections is descriptive. I aim to provide details of how science functions normally and the place of women therein. I am concerned with how gender relations shape all areas of scientific practice. Although these are two separate sections the distinction is used for convenience only. It is not meant to suggest that research practice can somehow be separated from the social relations of science. I would argue that research is fundamentally shaped by social relations, both within and outwith science.

The fourth section concerns the ways in which these women would like science to change, and the extent to which their wishes can be currently fulfilled. This covers all aspects of science already introduced in sections 8.2 and 8.3. It is worth mentioning here that the extent to which the women themselves see social relations affecting science shapes their analysis of the potential for objective value-free science. Women who argue for the traditional positivist empiricist model of science do not make a connection between social relations and research practice, whilst those who are more critical do not make a separation.

The fifth section concerns these women's views on feminist epistemology and theory more generally, particularly its relevance and usefulness for changing science.

8.2 Gender Relations: The Scientific Community

8.2.1 Lifestyle

Around 12 of the women practitioners and critics commented on the lifestyle of the scientist. The most common themes are about how women's lives do not readily fit in with the large amount of time required of scientists in order for them to succeed in science. This was attributed mainly to women's role as mothers and as members of the community more generally.

> Certainly women are traditionally, and I think that it is still true amongst professional women, women are still likely to have responsibility at home for the kids. Who makes the final decisions, I mean who sees it as their responsibility to organise child care ... is more likely to be a woman, and in that sense integration of their role as a scientist with other aspects of their personal life is going to be different. And a telling example of that would be looking at something like high energy physics [Sharon Traweek's work] ... there is this notion of beam time, so the team have to get onto the accelerator ... [via] time share arrangements ... and that may mean working through the night ... The implications for women are huge. (C1B)

This is not only relevant to high tech laboratory work, but can also be used to isolate women in a more direct way in any science:

> I was doing work on gaits of animals, for example, and we have a Kinesiology Department, and when I couldn't get a job I was really depressed because I really like doing research more than anything in the world ... and two of the people in Kinesiology came up to me and said, 'we'd let you use our equipment if you come when no one is using it, or maybe in the middle of the night', which I remember was a complete turn off and I just didn't think they would do that to a man, they would say, 'Why don't you come and join our research and we can get you something you want', instead of isolating me and making it obvious I wasn't wanted ... but feeling that they had to do something. (P2B)

It was felt by this respondent that the men's offer would be more helpful for a man than a woman. Another example illustrates how men can manage to deal with the commitments expected of them in science more easily than women:

> Men suffer from that too because they have families ... what Brian says I guess, he's got a fixation about keeping to that role, if he shows any deviance from that role this little voice in his head tells him he's not serious about science if he spends time with his kids so he programmes a certain amount of time for his kids, and that's it. He's heading for a crisis, you can't just run your life like that. (P4P)

The corollary of this situation is that for women to fit into science they may choose to adopt more acceptable standards of behaviour. In its most extreme form this can involve setting up a disjuncture between their biological and emotional self as this quotation illustrates:

> I was driving to work one day and I saw a woman who was pregnant and who was pushing a stroller and what went through my mind was, 'oh, what a boring person'. And then myself being pregnant in the car driving by I thought, 'holy shit ... I'm thinking about myself' ... I couldn't any more see myself as a man, or as an androgynous figure ... I really had to identify as a woman and that was profound. (P8B)

The choice between a career in science and a family is still a problem for women in science. All of this information suggests that success in science is related to suppression of a life apart from science. This is, of course, widely acknowledged in the women in science literature, detailed in Chapter 2, and has parallels in other professions that are traditionally male-dominated.

8.2.2 Style of Interaction

A large majority (24) of women I spoke to mentioned the issue of style of interaction amongst scientists. This can be subdivided into two main areas: support and networking, and most significantly style of collaboration in research. Looking first at networking and support, a common theme of women experiencing a sense of isolation from male networks emerged:

> When I was in Graduate school, every woman will tell you this, I was the only female in my class. OK for the first day the homework is due the boys are off working together automatically and they would say, 'oh we're going to go and do our homework', and they never asked me. So I played this trick, I used to invite them to dinner ... I mean is that classic or what? Eventually I just forced my way into this group and I became pals with them but it was not automatic. I remember another incident which I guess they all thought was wildly funny and I came back from class one day and ... open on my desk was a *Playgirl* centrefold - a naked man, which I was horrifically embarrassed about but I didn't make a big deal about ... it was just a real reminder, you can be pals with us, but you're not our pal, you're different. (P9P)

This experience of isolation increases as women move up the hierarchy in science:

> The further I've gone the worst its gotten. You think, 'Oh, I just have to make it through this one hurdle, it'll be OK, there'll be more women, women will be coming along', ... and what I've found is that its got worse the higher up you go. (P10P)

This can have serious consequences for women's success in gaining funding and promotion:

> There's nobody to look out for me to say that's the path I should take. Another thing that's crucial particularly when you get in a tenure track position is that none of the senior staff have ever said anything to me about what I should be doing or how I could advance, or, 'maybe you should be giving that talk, or writing that paper', no advice or anything like, 'gee, I think you're ready for tenure'... The only mentoring we get is if we go up and demand it, which is a hell of a hard thing to do, because these guys are not approachable. (P10P)

This woman continued to talk about her own involvement in feminism in science:

> In my own personal case I've pissed off a lot of people in fighting for the issue of women here, like protecting particular people here against particular things, or fighting to hire people ... I've made a lot of men angry, so then how do I turn round and say, 'gee can you give me some advice on how to advance?' and I look around at my male colleagues and they ... have got protectors never mind mentors, people who are holding their hands, both of them ... lifting them! (P10P)

So women's isolation for women can be exacerbated by involvement in feminism.

Another aspect of women's status in science concerns the reception of their work by their peers and technicians:

> I think when it comes to experimental design there's this kind of prejudice that girls will not be as good at something that functions [like] machinery or computers ... anything that's ... machine based. I think they expect us to have more trouble. Things like I've done drawings for workshops to get things built and [the technicians have] questioned me a lot more closely than they would a male ... I think things like interpretation of data, data used and ignored, I think that's got more to do with confidence than gender ... some of the other girls I've seen, as well as myself, tend to be less confident in presenting results, and therefore they sense that you're less confident and they question you more closely. I don't think it's because you're a girl, I think it's because you're less confident in presenting your data. (P12P)

However, I would argue, being a woman in a male dominated profession clearly contributes to lack of confidence, so gender is a factor here. If women in science fail to adopt standard confident and competitive behaviour their results can be subjected to more scrutiny than is typical and may even be rejected - this clearly impacts on the content of scientific knowledge.

Other women spoke of their adaptation to the competitive style of science:

> What do you mean by male? Do you mean like male gender: aggressiveness, competitiveness, curiosity, experimentation? These are just labels for behaviour that culture calls male ... so if a woman wants to behave like this she can go into physics, right? So she'll be culturally called masculine. So in that sense, to take cultural norms, what are all the things we have to do? We have to be loud, obnoxious, egocentric ... aggressive, competitive. (P4P).
>
> Self aggrandising! (P5P)
>
> Self aggrandising, articulate, verbal ... you know, all these things are traditionally called male behaviour. In order to do physics, yes, you have to behave like this ... I don't know how I could do it otherwise. I find that if I'm going to a conference and unless I [raise] my ... little voice ... I get ignored. Everyone is sitting there going, you know [puts on deep voice] 'let me show you this graph'. (P4P)

Another woman made a similar comment:

> One of the things that you have to learn is a rather macho trait - you have to be very tough, and just ... argue back ... I know the first time I got rude comments made about a paper I was in floods of tears, I was terrible upset, and my supervisor took me to one side and said, 'you just have to answer back', and I thought, 'right, I'll answer back', and I duly did. I learnt that, and then I got stroppy about it, and when you've learnt to get stroppy about it you can always pick holes in the referees' comments ... But, it's a macho trait undoubtedly. (C1B)

The competitive style of science shapes research as well as publications:

> I think [women will] be more [oriented] towards groups ... there will be more help, less fear of giving away information. A lot of men that I've come across will ... where a spread of information will be to the good of all, they will not do it because it's to their own detriment. (P12P)

Restrictions placed on information have repercussions in the type of scientific research that is done, and the conclusions reached.

A related issue is style of collaboration in research. Group work is the norm in most experimental scientific research; although scientists in particular research areas, eg animal behaviour, or with more theoretical interests, tend to work alone. Some scientists can choose whether to work alone or in groups, eg when working in materials science. Groups are arranged hierarchically and there are a range of scientists within each group with different levels of experience, including PhD students, postdocs, researchers and senior researchers, who are in control of the project. Membership of groups can change with different research topics. Sometimes groups collaborate and in some disciplines groups remain more stable. There is a competition between groups, and inter and intra group competition between individuals at the same stage in their career. Younger researchers tend to be particularly competitive, as this is important in establishing their career.

Twenty-one of my interviewees mentioned that the competitive and individualistic values in the process of group work was at odds with the more collaborative style that they favoured. Most argued that this was due to earlier gender socialisation, which they saw as encouraging competitiveness in men and collaboration in women. Non conformity to the stereotype was, however, noted.

Deviance from the typical approach in science can act to marginalise women:

> I'm in this collaboration at the moment ... with one woman and two men ... and the minute the men start the way they do, their ping pong game of this idea and that idea, I just don't play that game, I play a different game ... I communicate in a different style ... I find myself just shutting up ... so I know in those collaborations I appear as if I don't know what's going on ... especially in this one collaboration which was originally my idea ... I'm finding that they're getting together without telling me ... I'm just more and more on the side lines. (P12P)

Often women shed their collaborative style in favour of the dominant one in order to evade marginalisation:

> ... there are some more collaborative instincts and less competitive instincts that still come through [in women in science] but by the time you get tenure you'd be lucky if it hasn't been beaten out of you ... I just think the whole process is so self enforcing, so directing, it's very difficult to escape . (P13B)

However, adopting typical values in science still does not guarantee success for women. The following discussion portrays the ways acceptability is defined according to how 'appropriate' the scientists' behaviour is to their sex:

> In high energy physics there are quite a few women who have gained reputations for being obnoxious and so on ... when you're at the front of the room giving your lecture and there's 300 men listening to you and they start ... saying, 'you're wrong, how can you put that up, how can you say that?' ... a lot of men seem to feel comfortable with this. I don't. A lot of the women who are exposed to this, feel I think that they have to act the same way to be treated as a colleague. However I think the problem is when women start acting obnoxious and so on, they get these bad reputations. (P4P)
>
> I've been called a 'pushy broad' to my face ... with a witness. (P6P)

> Well there's this good example ... in high energy physics a woman had applied for a job here a few years ago and she's from Harvard, and from what I understand she was trying to get ENSERC funding for the grant but she went to some meeting where ... the administrator for science and technology was there, and she hoped, I guess, to convince him to get the money flowing her way and he just looked at her and said, 'you're the most obnoxious person I've ever met', and of course she didn't get the money. (P4P)

> If acting feminine in the sense of being demure and quiet rather than aggressive actually got you ENSERCs and attention and consideration, then maybe we'd be acting more demure ... well it doesn't ... so you end up acting in a way which is closer to the already established way of behaving in physics which is male. (P5P)

This is a classic 'Catch 22' situation: to succeed in science women (and men) have to adopt a particular style of interaction. However when women do this they can be penalised, even to the extent that they do not get funding or promotion, as these characteristics in women are unseemly and, apparently threatening to men in science. These women clearly perceive a link between stereotypical masculine values and those expected in science. However, as is the case in wider society, when women exhibit 'masculine' behaviour it is seen as excessive and inappropriate.

Once more, the style of interaction amongst scientists can affect the content of scientific knowledge:

> Some feminists who don't challenge the basic view of science nonetheless run their laboratories quite differently from the way men do. That in itself might affect the science they do and the way the science gets done. I mean, if the relationships are more open and other people have more of a role to play in the formulation of questions and things like that, then I would think that would clearly make a difference than if you had a very hierarchical top down model. Again, which isn't to say that all women are non-hierarchical and all men are hierarchical, but I do think in general there often is a difference. I think that would impact on science even if women accept the reductionist framework, so I think it's really a political issue, certainly not a gender issue, except to the extent that gender is political. (C2B)

The social relations that have an effect on scientific knowledge can come from something as basic as the organisation of the laboratory.

8.2.3 Student Relations

The main issue, mentioned by 6 women, about the way scientists interact with students was sexism. The most harrowing example of this is as follows:

> I was the only woman in theoretical chemistry at the time ... I had a lot of problems with sexual harassment on the part of a particular faculty member. I had mobility problems at the time ... in the February of my first year [Masters] he offered me a ride home and sexually assaulted me ... I didn't know what to do. I decided quitting was not an option ... there was another student who quit because of the same professor ... People would probably admit that this guy's behaviour was inappropriate but no one was willing to do anything about it ... I did my best to avoid him .. in certain respects he stalked me ... to the point that I was afraid to work in the building after hours, and that's pretty essential when you're a graduate student ... The harassment continued, there were phone calls basically saying that ... he was chairing the Graduate Studies now and my life would be a lot easier now if I got to know him a bit better ... now the University has processes in place to deal with this kind of thing but in the late '70s it didn't ... even when I was away from the University working I continued to get phone calls from this guy. One day he was at the end of the walkway [where I live] so I went to the Rape Crisis Centre and they helped me do the spade work for a civil harassment suit and once I made it clear to him that I was prepared to follow through then he stopped. (P14C)

In practice the existence of processes to deal with harassment are only a partial solution. The repercussions of complaining are not to be taken lightly:

> I think ... if you complain ... you just get a big backlash against you ... One of my students was in a civil harassment case that happened in December ... it really destroyed her next term and she didn't come back to University, so that doesn't seem to be a good solution, and she won, many of them don't win, and by winning they said they wouldn't rehire this sessional man who had been harassing her. (P2B)

Other women spoke about weaker degrees of sexism such as sexist comments and reduced expectations from women students. However sexism at all levels of severity still plays a role in excluding and isolating women science students.

Women may also be more inclined to support students, and organise their laboratories differently to enhance the effectiveness of their teaching:

> I was talking with a technician ... who has been working here for quite a while ... [and she commented] that she perceived me to be much more interested in the educational aspects of running a laboratory [than a male colleague]. I think she was also referring to the human connection ... I have a former PhD student who's now postdocing with ... one of the world's top entomologists, and ... he commented to me that I take a much deeper, more profound interest in the welfare of my students ... it's generally recognised that in my lab the culture is non-competitive. In fact that's quite difficult to do sometimes, because of the nature [of the relationship]. When there is a senior person there is a tendency to ... compete for attention and favour, and it's not always easy to prevent that ... But I think that I certainly don't try to enhance it, as a tool to get people to work harder, or whatever. My sense is that what I'm talking about [is that] there are differences in terms of the management of activity, the conduct of research, and also in terms of the choice of problems and the manner in which they're pursued. (P16C)

Interestingly, this difference in approach between male and female scientists also has the potential to affect the content of scientific knowledge.

8.2.4 Scientists in the Wider Community

The third and final issue concerning the scientific community that a few practicing feminist scientists talked about was scientists' position in the academic and local community. As discussed in Chapter 3, scientists are an elite group with a vested interest in maintaining a position of authority that seems to revolve around their 'neutral' stance. This woman described her experience of hostility to her involvement in a course on Women's Biology that was considered sociology, not biology by her male peers:

> People really do have this sort of belief that natural sciences are sort of above and beyond ... they're neutral and objective ... and also ... I don't know what is behind this, but politically scientists tend to be to the right of people in other disciplines and so anything that seems to imply a sort of social participation seems to be highly offensive on political grounds. (P17B)

In my view it might be that this hostility arose because social participation implies science is social knowledge, as opposed to neutral and objective. The maintenance of the image of the objective word of the scientist in the wider community is important to scientists, and must be protected:

> There's a lot of resistance [amongst scientists to increased public participation] and many scientists say that the kinds of decisions that are made are too technical and you need too much knowledge to make them accessible to the general public. I disagree - I think that there are a lot of value judgments buried in those decisions and that they are indeed accessible to the public - especially informed members of the public as many advocacy groups become. (P13B)

The reasons for scientists' desire to protect their neutral image are clearly related to a protection of their status and power in society.

8.2.5 Employment Hierarchy

Roughly half of the women I spoke to mentioned the employment hierarchy. This is a hierarchy of qualification and discipline: from Professor to research assistant. Permanant (or tenured) positions are also more prestigious than temporary positions.Teaching is also of less status and value than research as publication rate is the main determinant of position as opposed to good teaching practice. The disciplinary hierarchy, which is more informal but nevertheless powerful, places so called 'soft' sciences, from sociology through psychology to biology in ascending order, followed by chemistry and ultimately physics. The following quotation illustrates this hierarchy:

> There's really huge barriers, because whenever you talk about anything real in biology then it's called sociology. I know that way back in 1978 at my very

> first evaluation as a Professor when ... at that time I was one of two people who had outside grants for doing biological research for the Science Council and I'd done all my teaching ... and I'd done all the things I was supposed to do and somebody put a black mark on my evaluation saying I wasn't really doing biology I was doing sociology ... and at the time I was doing fungal research on mosquitoes but they were mad at me because I was teaching this course on Women's Biology. (P17B)

These barriers can also mean that the 'core' sciences remain the least 'contaminated' with politics and social values whereas the more marginalised sciences, eg Biostatistics, are more open to feminist influence and women scientists (P18P). The history of women's involvement in crystallography is one such example (P18P). Note also that in this case, although teaching is generally less valued than research, 'heretical' teaching is used here as a reason for denying promotion. The hierarchy is flexible when it needs to be to maintain the status quo.

The main issue for women's employment in science departments in universities is what (P18P) describes as the 'augmenting exclusion effect'. This is where the numbers of women diminishes as one moves up the hierarchy. For women there are several reasons for not moving up the hierarchy: women may not place so much emphasis on a career in science. It is easier for women to opt out for a variety of reasons like wanting to have children or, more likely, disillusionment with the high work load and stress levels associated with working in science:

> I think [men] feel the same way [about the structure of science] but I don't think they ever think about opting out, whereas I think we think daily about that ... they say, 'I'm going to follow these rules because I have to, I'm going to stay here, I need this job, this is my life', whereas women are saying, 'well, this could be my life, but I can always opt out'. (P11P)

Women are also, typically, less confident, and there is evidence that fewer women than men are actually applying for senior jobs (C1B). This is also common in other professional areas.

Although some women opt out others are clearly pushed:

> Now ... why is it [that women leave science]? I mean you can speculate - we don't know whether they're choosing to leave, 'oh gee, I've just worked my butt off for 5 years getting my PhD and now that I've had that much fun I think I'll just go home and take care of the kids'. To me that just doesn't ring true, I think it's just an excuse, but it's possible that women choose to leave astronomy for some reason more than men, and it's possible because they're not being offered the jobs. (P9P)

This is certainly a factor, as 10 of the interviewees argued, some of whom had been actively discriminated against in gaining tenure, for example:

> After gaining my PhD I got a job teaching at the University and everything was going fine and I published a lot of papers, but then when I'd taught there for about 4 years it came time to get tenure, and although I had about 20 papers at that time they wouldn't give me tenure, and I thought, 'this is weird', because they were giving it to men with far fewer. (P2B)

Two other women were also denied a place on physics courses at university because 'women don't do physics' and opted to do chemistry instead.

The reasons behind this kind of discrimination are complex. One respondent refers to the 'old buffaloes', or the 'high quality senior peers' if one is more polite, that decide who gets promotion. These are the father figures at the top of the hierarchy:

> [Science is] hierarchical, it's patriarchal, it's that old system of the hierarchy where the access to knowledge depends on rank and the lower ranks know less that the upper ranks and the information is carefully distributed ... by this very broad system of teaching and by not considering any knowledge that is not transferred in that hierarchy as valid knowledge. (P18P)

This also means that success is somehow dependent on similarity with those at the top:

> You need to get in a gate ... now there are gatekeepers and the gatekeepers tend to let people in who are like themselves ... and this is very damaging to science because what you do is you clone yourself. (P11P)

This club is not necessarily exclusive to men, because as we have seen in the previous section women scientists can adopt accepted values:

> I used to think that getting more women into science would change it, but it hasn't. Not that there are lots of women in science, but many of the women who join science, partly because of the very rigorous approach to tenure, by the time they come out they think, 'well, I went through all of this shit', and they develop a commitment to the system that exists because they are now beneficiaries. (P13B)

This also means that women who get to the top in science do not necessarily see any need to help other women at the bottom, they did it on their own, so why can't others?

However, not all women get their politics 'beaten out of them' (P13B) as they get through the promotion system, as 4 of the women interviewed demonstrated. These women have a common experience: in order to get through the hurdles to promotion they had to put their feminism on hold (P16C, P18P, C2B, P13B). It is only once they achieved tenure that they began to bring their feminism into their work in science.

Another interesting feature of the employment hierarchy is the way that boundaries between different levels shape research science:

> I had a similar collaboration, also led by a man who would not let communication happen among the ranks. I had to go through him so that he could contact this somewhat famous astronomer in Europe ... who was doing a spectroscopy ... and he would not let me contact him ... and I was very upset by this . (P10P)
>
> But how could he stop you? (P11P)
>
> He wouldn't give me his e-mail address! I was in Edinburgh and needed to find out a part of the other project and ... under no circumstances was I to contact this person ... that did affect the way the science was done because I couldn't get the information I needed about what objects to select and so forth. It was important that this fellow should be seen as PI [principle investigator], seen as in charge of everything and in control of the flow of information, so it did have

> an impact on my science, and affected the collaboration ... there is an impact on the science - the style has an effect on the science that's done ... in the environment where this kind of hierarchical structure is imposed, it doesn't allow me to think freely, to brain storm. (P10P)

Note that intellectual interaction in science is a crucial resource for developing new knowledge, as well as for career advancement. The social relations of science, eg the hierarchical structure, clearly affect the type of science that is done. As we shall see, funding is another example of this type of interaction.

8.2.6 Funding

The premium on high publishing rates and correct results is an important structural feature of science (P9P, P11P, P4P, P6P, P15B). In the case of publication there is also evidence to suggest that papers with women's names are not valued as highly as men's (research paper mentioned by P10P). However, interviewees tended to talk more about funding, or the 'research rat race' (C3B).

Important features of funding seem to a preference for 'big science and big grants', ie large grants for a small number of acceptable large projects (P19C, P13B, P11P, C1B, P17B). This means funding is highly competitive and requires a lot of self promotion (C3B, P8B). Maintenance of this involves several interest groups:

> I think that some of these vested interest are individual vested interests on the part of some scientists who want to maintain their own careers ... of people have invested ... a great deal of their life's work in a certain research field then its important to them that the credibility of that field be maintained and the funding for that field be maintained, so there's an entrenched vested interest there on the part of the academics who are already successful. But there are also political and corporate vested interests that also operate on science through funding ... so all those things act to maintain a fairly traditional approach to science and that's where any resistance to any new approaches [occurs]. (P13B)

The 'cloning' continues in the field of research funding as in employment promotion.

It is also worth noting how funding is a key determinant in what research is done. Some women I spoke to resented the way economic considerations determine the science they perform:

> Asking for money has totally changed the way it's all done ... that's a problem in all areas ... economics has made the people that we serve different, we're no longer serving nature and understanding, we're serving bureaucrats and funders ... I think it's harder [to be creative now] because you are so busy watching your professional profile. (P9P)

> Also I think that you can't be wrong - that's part of the problem ... we have fostered a way of doing science that you can't say outlandish things ... only when you get to be that crusty old professor ... with an impeccable reputation, then you can say what you want ... if we started saying things that were a little beyond the pale, our careers would be over. (P11P)

Publishing commitments also restrict the type of science that is done:

> It's not just that, it's all the time - you have to publish so many papers a year and if you don't spend all your time doing things that you absolutely know inside out and have results [for] - in other words, not new or creative things - you can't keep up that rate. (P10P)

Formal social relations in science also affect research practice in fundamental ways.

> Scientists are very restricted ... people are very fortunate if what they are told to do and what they are encouraged to do is in fact what their own interests are ... and that pressure comes from within science ... people whose work is considered interesting is funded ... people whose work is not considered interesting is not funded. It's not just a question of quality for funding, it's also what do people find interesting, or of value? (P19C)

This clearly restricts scientific research to particular projects, compatible with the interests of the socially and economically powerful in society - a particularly small group of white, upper class men.

8.2.7 Conclusion

There is a web of connections between all the issues discussed around the social relations in the scientific community and beyond. The lifestyle of scientists, networking and style of collaboration and interactions with students and the wider community, as well as the hierarchy of promotion, funding and publication, are all interrelated and cannot be considered in isolation.

There is also important evidence to show how these social relations affect scientific knowledge. This includes evidence that women scientists who are under confident are more likely to have their work closely scrutinised, which has the potential to affect the content of scientific knowledge; women who do not fit into the dominant style of interaction can end up marginalised and their input into the content of science will decrease; more generally the style of interaction in a group will affect the choice of problems and conduct of research; the need to maintain hierarchical boundaries can have a similar effect on scientific knowledge; funding is a key determinant of what research gets done; and, finally, results are also shaped by the pressure from the external funding bodies and the scientific community for new, coherent and useful information. Not all of these issues are always gendered, but gender clearly plays a part in as much as science is male dominated. Male scientists appear to have more interest than their female colleagues in keeping things as they are, as it is male scientists who reap the benefits.

From these interviews it emerges that a common thread binds social relations in the scientific community - that is their association with characteristics of competitiveness and confrontation and hierarchical structures. These are also stereotypically 'masculine' values. Science is not gender neutral, and instead seems to have a closer fit with a typical male lifestyle and 'masculine' style of interaction with other scientists. Again it is shown that it is clearly easier for men to succeed in science. However women can also succeed in science if they 'play the game'. In other words these women can also adopt 'masculine' values throughout the process of socialisation as a scientist. Women can 'buy into' the system; a process that can tend to reduce support women might give to each other. However, women's acceptance of masculine values in science does not necessarily guarantee success, as women can also be penalised for breaking codes of acceptable female behaviour. Men as well as women may leave science if their behaviour is not legitimate. The male domination of science also brings with it sexism directed against female students (and colleagues) and generally creates a hostile environment for women. The issue of scientists maintaining their position as an elite in the wider community is not directly gendered in my discussions with these women, but the relatively powerful position in society of predominantly male scientists must be recognised nonetheless.

There are clearly powerful traditions in science, that are reinforced through generations of scientists. Male and masculine is still the favoured sex/gender of the scientist. I now move on to consider gender and research practice. I hope to continue to show that there are links between gender issues raised in this section and what follows.

8.3 Gender Relations: Research Practice

In this section I consider how gender relations might affect scientific practice. This has several aspects, the most important of which can be grouped under the following headings:

8.3.1 topics and questions
8.3.2 control of nature
8.3.3 objectivity/subjectivity
8.3.4 reductionism/holism

This involves a description of women's perspective on how research practice functions 'normally', and of whether they practice science differently from men. What is the role of gender in research practice?

8.3.1 Topics and Questions

There was a large amount of discussion about the topics and questions in science (by a total of 17 women). The main subject was the way scientist's background, specifically their sex and gender, affected science.

The majority of the women interviewed made a link between scientists' values and the topics and question they focus on in science. For example, 2 practitioners argued that women want to look at different problems in science because of their upbringing:

> Why would they not, out of their historical social experience, how they were brought up, how they were trained, how their lives go, what their fathers and their mothers give them, as an idea of their expectations, ask different questions? (P18P)

> Given the same set of information girls and boys will possibly identify different problems - it's perhaps not surprising when we rear and nurture girls so differently, that they have different world views, different concerns. (C6C)

Others argued that any possible differences in the sexes' world views are limited by the way science is organised:

> In the biological sciences that I've seen I wouldn't have said that there was necessarily a difference between women and men, I think where the difference would arise is where those people that might question the scientific paradigm, people like feminists, might ask a different set of questions ... things like gender differences in the brain, or differences in homosexual brains ... I'm sad to say there are a fair number of women who do that ... my feeling is that, at least for women, it's about .... that notion that you've got to take on board the idea that you have to be a real scientist and think about these kinds of things. (C1B)

Politics, which are not necessarily to do with gender, may be the driving force behind some scientists' choice of topics, as this woman's story illustrates:

> Much of the work I did in terms of energy transfer and damage was too closely related to both atomic energy and the military ... for my liking ... and I didn't want to do that sort of work even if I didn't apply for grants for the commercially confidential or militarily restricted work. I've always been the only one in my department that did not apply for anything that was sponsored by the atomic energy commission or anything related to that or any branch of the military. All of my other colleagues did that, and when those guys came around they eventually accepted that I just would not go to the meeting. So I've always worked with a very small research budget, but I began increasingly to use the techniques of modern material science on ancient materials. In the first place largely because it was a field which was absolutely impossible to prevent in war terms because it dealt with the past ... there wasn't a thing that anyone could pervert into war [use]. (P18P)

Note here that the majority of the other scientists appear to be more apolitical than consciously political about their work in military research. It is worth considering further how funding shapes research topics:

> In terms of the funding, the direction of funding comes from the white papers and policy makers ... if they decide to put more money into defence then projects which ask for money for defence are more likely to get funded ... I don't think [that] in physics, it's very easy to separate the aspects of the policy making from the individual aspirations. (P15B)

> I think that part of the problem is that people tend to go for research where they can get funding ... hence Aids has been a good one and people who might not necessarily do Aids research do it because they can get loads of money ... my supervisor's like that - he has someone on an Aids project simply because you can get money for it. (P20C)

Focusing on military research, as an example, there are a number of issues. One woman explained how women are less likely to become involved:

> I think men are more likely [to go into military research due to an interest] in how much they earn ... there's a lot of money in it, most of the women I know have deliberately avoided it. (P12P)

Three other women also said that they did not think women were as likely to do military research (one of whom was a physicist). Four other physicists (P3P, P2P, P5P & P18P, quoted above) said they personally would not do military research (although one was working in an area with potential applications - lasers) whilst only one had worked in defence (P4P). The woman working in lasers spoke of her disillusionment:

> I must admit I'm finding it more and more difficult to motivate myself with my work. What do I care if someday somebody makes a switch that's twice as fast and we can send information down an optical fibre twice the speed we can now? To me its becoming more important that I can work in an area of physics where I feel it's going to make a difference to society. (P5P)

The problem for women in physics is that it is relatively difficult to avoid military research, and some have to make compromises:

> I didn't see anything bad in what I was doing ... I mean I wouldn't go out and be part of a team that would build a nuclear bomb ... but tracking ships ... that's more in case something goes bad ... its different from building a nuclear bomb . (P6P)

For many women with a social conscience this is the kind of compromise they may have to make to stay in physics.

From these descriptions there is no clear association between topics in science and the sex or gender of the scientist. Any differences that might arise from upbringing are blurred by the compromises women make to stay in science. Political sympathies, rather than gender, seem to guide a small minority of scientists into, or away from, various research topics. The vast majority, however, appear not be consciously political about their work, and are driven by a variety of reasons for working in particular areas, eg available funding. It is difficult to draw a link between topics and sex or gender in some branches of science that have relatively large numbers of women - areas such as astronomy. Astronomy has no apparent link to the living world, and tends to be highly impractical, so this cannot be used as a reason for women's involvement. Neither is there any reason to assume any mystical link between women and the stars. The reasons women have been in astronomy, as opposed to the other hard sciences, in relatively large numbers, from the 18th century onwards, is more likely to be linked to other factors, such as familial connections (P10P).

However, topics in science may still manifest a 'masculine' world view (which women in science and funders could also adopt):

> What I notice is that the questions women ask are not readily covered by existing research projects. Now that's terrific for me because it means I get to think of all these interesting questions that they've never thought of because nobody's ever talked to a worker ... and I get lots of money [mainly from Quebec Unions] because they're original and exciting questions. But it also says something about how science is run and how decisions are made about what funding to give and what's interesting and what's not interesting ... [on] funding organisations ... there is very little room for client participation ... For example, you don't have groups of people who are represented on research into social welfare. (P17B)

> I think that Western culture isn't holistic in its approach and that certain kinds of questions don't ever get asked ... the parts don't necessarily give you the whole. (P15B)

The definitive features of Western society that shape the topics of scientific research undoubtedly involve the capitalist economy and the way in which the powerful positions are dominated by men. However, as I have illustrated above, the majority of scientists, male and female, are not in a position to be discriminating about what kind of research they conduct. Only a strong political commitment will lead then to search for particular fields that do not compromise their views.

8.3.2 Control of Nature

I have already noted that funding is a major factor shaping the aims and objectives of science. Scientists' need to publish research, and the style of interaction between scientists, also shapes the aims and objectives of particular scientific projects. Here, I explore any other factors that might shape scientific knowledge. I have chosen to focus on the popular feminist claim that the masculine desire for the control of nature determines scientific practice. It is as a basic aim of research that 'control of nature' might shape the entire content of scientific research (including the results). Four illuminating themes are worth considering in some detail: the link between control of nature and prestige in the scientific community; male ego and control; different contexts of control; and the rhetoric of control, as opposed to the reality. The first group discussion involved the first two of these themes:

> It's my view that [science] somehow appears out there as dispassionate and lacking human contact, because, and I think there is a gender difference here, it has to do with conquering nature versus understanding nature. I think that it's a product of ... male ego, the need to feel superior and on top of it and in control of the situation that leads somehow to this male intellect that's imposed ... and I will say this is not my experience. My experience of the way I do science, and of many women that I know, and some men ... [is that we] feel more in awe, more subservient, more in the service of understanding what it is out there ... but I think unfortunately ... the ones who manipulate and assume that role of power are the ones who get the funding, the promotion, because its a sort of battleground out there. (P9P)

This woman is arguing that men need to control nature in order to feel superior, and reinforce their fragile egos. She made a link between control of nature and control of power in the scientific community. Another member of the same group of women gave an example of how men in science exhibit this 'need' to control:

> I remember hiking once on a mountain in Tenerife, on a volcano, and we were walking down there and there were these unusual snow formations, they were spiky, funny little shapes. Instead of saying, 'Wow, that's really interesting', or whatever, these guys were saying, 'Mmm, I think the sun shines from this side...', or, 'No, the dust comes from this side', and they were virtually writing a paper for *Nature* on the way down the mountain ... Over and over again, it's all, 'Can we conquer this? Once we've defined it and explained it, I'm done with it'. (P10P)

Here 'control' was equated with providing an acceptable explanation (in terms of peer group evaluation) for natural phenomena. This contrasts with the views of one woman in this group, who made a distinction between astronomy and other hard sciences in terms of their ability to control nature:

> About your biggest difference between astronomy and the other hard sciences is ... we have no ability to really control our laboratory. It's basically out there, and we can control how we measure it, but that's all we can control, and that's really fundamental if you're trying to do experimental physics. (P11P)

In astronomy there is a lack of control of nature via experimental design, but, the above comments suggest control may be achieved through providing acceptable explanations of natural phenomena.

Other discussions of control are less concrete. Two other women also linked what they saw as men's 'need' to control nature with science. One (C6C) gave an example of a woman who shut down her research lab after deciding that she no longer wanted to work with her male colleagues in improving trees, and wanted to work on how to preserve them instead. This interviewee also argued that the 'Master molecule concept ... [is] related to men's need to control ... the way we rear boys into men means that they have to be in control'. Another woman made a similar point 'men just tend to think of themselves as being so far above ... in control of nature' (P20C). One other woman, who has just had a child, made a similar argument and linked women's understanding of nature with their biological sex:

> I think [with] the process of pregnancy and childbirth, whatever you've thought before, is going to have an effect on how you react afterwards to

natural processes ... women are forced to be more involved with nature. (P21P).

And ... have you taken that into your work as a scientist? (AK)

No .. not really ... I think I've always thought that it was better to work with nature ... but on the other hand I also think it's important and exciting to go out into space and there's an immediate conflict because progress requires some manipulation [of nature], so I've accepted that virtue sometimes goes with what they call the naturists, but on the other hand I think that we, naturally as human beings, will take on the responsibility ... I would argue in terms of responsibility ... whether men are more responsible than women about controlling nature and how far they will go ... I think that perhaps the fact that you're a woman and you're closer to nature ... means that you'll be more cautious in the steps you take to control ... so I think there is a difference. (P21P)

The theme of male need for control remains, but from a different perspective: men have a more responsible approach to nature as a result of their alienation (in contrast women are closer to nature, and 'less objective'). Note also that this interviewee did not think that her 'closeness to nature' shaped her practice of science. In addition, the conflict between good and bad aspects of control is also introduced, and echoed in the following quote:

I don't think control of nature ... is ... necessary [in science] ... unless ... well, that's a difficult one, because ... it's good if you're controlling disease, but then ... do you terminate a fetus that has a disease? (P12P)

Here the notion of technological control, as distinct from experimental control, is introduced.

One of the respondents' views of the relationship between control and understanding are also interesting. This woman argued that the idea of control in science is unachievable, and distinct from understanding:

The idea of controlling nature, and the belief that we will ever get to that ... [is] a consequence of the reductionist philosophy, and indeed, of the reductionist methodology ... I have always wanted to believe that nature will have the last laugh ... there's part of me that doesn't want the brain to be completely explained, and probably it won't ... because ... we have levels of understanding and we're never going to integrate all of them. So ... I don't want to be able to control nature completely ... understand it, but not to control it. (C1B)

An interesting contradiction arises here. Initially control is linked with understanding (the function of the brain) but later in the same statement a distinction is made between understanding and control.

Finally, the links between masculinity and control may be rhetorical:

In the history of science I suppose [control has] become associated with [masculinity]... in ... the sort of things Bacon wrote about, but it's also about the rise of Capitalism, so it's not exclusively a male thing, no. (C1B)

From these women's descriptions 'control of nature' in the context of scientific practice clearly can have several different meanings. Notably, the links made between masculinity and control, in addition to the links between understanding and control, are flexible, and few of the comments are grounded in concrete examples of practice. The implications of this will be discussed further in Chapter 9.

8.3.3 Objectivity

I now move on to look at one of the major themes in this thesis: objectivity. I consider the main aspects of scientific practice: including research design, methodology, data taking and analysis. Note that objectivity encompasses several different concepts in science. 'Being objective' is thought of as being unbiased and neutral when observing natural phenomenon, and is valued highly, as it is seen to give better, more factual results. This is linked to keeping politics out of science, and also separating knowledge from experience more generally, particularly emotion and feelings (be it the experience of the actual scientist or the subject of investigation). An impersonal and dispassionate approach is instead favoured. The women I interviewed described science-as-usual in these terms. A particularly telling example was the following anecdote where native Canadian elders' knowledge is contrasted with scientific knowledge:

> The native elders [in the Canadian Arctic] and the biologists disagreed [about] the size of herds of reindeers ... derived [by the elders] from how much bark was eaten off the trees and so on ... eventually the wildlife biologists went back because the native leaders said, 'our science points to much larger herds' ... [the biologists] did the [calculations] again and the size was large ... in terms that native elders had said ... That's the consequence of science being an enterprise that separates knowledge from experience, and of course that's the glory of science ... someone can learn to build a bridge from someone who's never built a bridge [via a book]... But there are things that can't be treated like that, and through the success of science we are now left with a body of practitioners, most of them men, and all of them trained in that hierarchical structure, and a set of unresolved problems because the methodologies they've worked on were applied and applied and applied and the problems were generated in order to make the methodologies work. (P18P)

Here the premium placed on objectivity by modern science is contrasted with more traditional forms of knowledge, which rely on empirical knowledge and experiences. The elders' tacit knowledge of the forest and the herd was seen to be important in their analysis of the situation. In contrast, modern science was viewed as involved with the application of set methods, based on previous research, for understanding natural phenomena, and, in effect, a different kind of tacit knowledge, based on *scientific* experience.

All of the women I spoke to maintain that the objectivity of science is a myth, as scientific practice does allow values to permeate knowledge. Although there was disagreement on the extent of this permeation, and the links between masculinity and objectivity, all agreed that objectivity should be the ultimate aim of science. I now explore these three themes in more detail.

The following discussion concerns the place of values in science:

> Taking data and analysing I think are pretty objective - those are the tools we learn, how to measure the spectrum, how to plot up the results - but there are subjective parts at the ... beginning and the end which is the choosing of the

> problem and the interpretation of the results ... I think it's a shame that science is portrayed as reductionist and somehow dispassionate because it is absolutely subjective ... at the beginning and the end points, and whatever you see up there in nature is going to be a product of what your eyes and brain are able to see and interpret ... I think that any scientist will say that it is, at a very personal level, very passionate. (P9P)

This is an interesting view of scientific objectivity on three counts. First the objective part of scientific investigation is viewed as the data collection, and statistical analysis, whereas subjectivities are seen as shaping the scientific knowledge as they determine the problem choice and the interpretation of the results. Second, subjectivities are linked with personal emotion and passion for scientific research, ie the desire to find a good answer for a fascinating question about how nature works. This passion shapes scientists' questions and answers. Third, subjectivities are seen as personal in another way - 'what your eyes and brain are able to see and interpret' - ability and personal 'quirks' in the way thoughts progress shape scientists' interpretation of their results.

In contrast, another woman argued science is concerned with objectivity and this is no more associated with men than women:

> I think whether one defined science as female or male depends to a large part on what one understands science to be. I understand science to be simply asking questions and finding out the answers in ways that are objective, and in that case I think absolutely it is not male or female ... I'm just almost insulted by that, because of course women can do that as well! (P9P)

As I have already argued it is important for women in science to stress that they can be just as objective as men:

> I hate to think that women wouldn't be as objective ... and I don't have any evidence that they wouldn't be ... thinking of objectivity as the opposite from emotionality ... I would be really upset if I found that women were somehow more emotional, therefore somehow that affected their science, because I guess we're so trained that you have to be objective to be a scientist. (P2B)

The links made here between emotional suppression being necessary for objectivity, also contrast with the earlier view of scientists' passion for their work.

Nevertheless, links between objectivity and masculinity were drawn by some women. Once more, the main issue was emotional suppression:

> If [objectivity] is standing back and separating oneself ... one cannot do this ... they're not recognising how a psychological, emotional factor is intervening here, and I think separation is a psychological and emotional need for males. But I don't believe the science they produce is therefore better. I think if one recognises the self involvement in it then one is likely to be more objective, in the way I think of as being objective, that is taking into account all the aspects that are there. (C6C)

Objectivity was seen as a dispassionate approach to nature. This is taken to be a male psychological need. But, such separation is viewed as impossible, and scientists' attempts to deny their *self* involvement, are considered as contributing to bad science. In contrast, the best type of science is perceived as being one that involves a thorough exploration of all of the ways in which the scientists' 'self' is involved in their view of the natural world. Note that in a certain way the goal of objectivity is not entirely rejected. Transparency in scientific knowledge claims is not unrelated to the notion of impartiality. Once other scientists have all the information about what has shaped a particular piece of research, a more 'objective' evaluation of the science can be made. The theme of emotional suppression continues in the following quote:

> There is desensitisation of the biologist as part of their training, how you have to learn to pith the frog without showing any emotion ... Michael Lynch ... did an ethnographic study of neuroscientists working with animals in the lab ... and ... they never write about it of course ... the rather disgusting language ... of jabbing a rat with needles and ... throwing it around and saying, 'oh, this one's fucked', and so on. There are some fairly gruesome descriptions from their verbal speech, which of course never appears in the written paper ... [which] is full of euphemisms like sacrifice ... I've written some stuff on the ways that [those] kind of attitudes are masculine ... they're part of the ... macho cult that I think is undoubtedly there in the laboratory, I mean I've seen it ... if you can't stomach it you're being effeminate. (C1B)

This woman viewed desensitisation of the biologist to the pain they inflict on animals as part of their training to be 'objective' scientists. A link was also drawn between machismo and lack of sensitivity.

Others were less sure of any link:

> I guess I couldn't say yes to that [question, 'is objectivity male?'] ... the reason is if you look at the women who are in science now, by in large they're using the same methods. What it represents is not so much men and women but it represents the way that science has been done in the past - there's been a pretence of objectivity ... which isn't all bad ... many of the methods in statistics that guard against bias are good ... I don't think they should be thrown out ... I would like to be able to say that this is the male way of doing science and this the [female] way ... all you have to do is to admit more women into science and it will change, but I don't think that's true ... I think you have to change the way science is, I think that men and women have to work together to change the way that science operates, and I think there's an increasing number of men who would also like to see science opened up ... Although you might want to associate the pattern of behaviour with maleness rather than femaleness, I think it will require a big change in both men and women's behaviour ... that will benefit both men and women. (P13B)

This respondent regarded the association between men and objectivity as historical, and viewed it as unrepresentative of the situation today, given women's use of objective methods. In a way, she wished it was as uncomplicated as science being a male way of doing things and becoming neutral when more women entered, because it would be easier to solve. However, women's adoption of orthodox methods and some men's rejection of these methods complicates the situation. Her argument that not all features of objectivity are bad, eg guarding against statistical bias, adds further complexity to the picture of gender and science.

Another interesting interpretation of the links between masculinity and objectivity was that it is rhetorical:

> The idea that science is objective I'd say is pretty wrong, and it doesn't matter if it's male or female doing it, it's subjective ... in that regard I don't think of it as being objective and feminine as not being objective ... [and] emotional. But the thing is how we do science and how science is defined has been done

> almost exclusively by men in our history and so its not surprisingly that men define it as being objective and then women don't fit into that definition ... I think that we are all fairly subjective, we try not to be, we try to be objective in those final stages, but I realise all the while it's so common that people find what they're looking for ... they find what they set out to find and they do it well. (P11P)

Once more the subjectivities of scientists (both male and female) are seen as colouring their interpretation of nature. The link between objectivity and masculinity was seen as a deliberate attempt by men to keep science a male preserve.

Three of the respondents (P21P, P1B, P12P) also argued that the 'harder' sciences are more objective in the sense of being gender neutral (primarily because they deal with inanimate objects and it is more difficult to add a 'social' dimension to such science); although respondents did concede that there is a problem in all science of, 'finding what you're looking for' (P21P). In other words physics was seen by these practitioners as more 'gender-objective' but not more 'scientifically objective'.

This information builds an elaborate picture of the complex nature of objectivity in science and of the relationship between objectivity and masculinity. Science is clearly not perceived to be objective, but to be bound up with subjectivities. The emphasis on how passion for science and personal 'quirks' shape scientific questions and explanations is important, as is the view that scientists 'find what they are looking for'. Nevertheless, interviewees identified different 'levels' of objectivity. Some of these levels may be more achievable than others, eg rigour in data collection and statistical analysis to eliminate statistical bias. Others argued that different disciplines of science may be more objective about certain factors, eg the 'hard' sciences could be more gender-neutral.

The association of objectivity with masculinity is equally complicated. Scientists' desensitisation to animal experimentation was linked with machismo and it was suggested that the pretence of separation implicit in objectivity is a male psychological need. The historical association between masculinity and science, especially the association made by male scientists in their rhetoric about links between objectivity and masculinity (to keep science a male preserve), were also highlighted by some practitioners.

8.3.4 Reductionism and Holism

Another major issue in research practice is reductionism and holism. To recap briefly, a reductionist approach, or model, focuses on a small aspect of the whole, for example this might be the dominant molecule in a group (the 'Master Molecule' as Keller has labelled the concept) as opposed to focusing on the interactions between all of the molecules. Reductionism can apply at different stages in research, for example research questions or interpretation and analysis of data could be reductionist. Reductionist models and metaphors might also be used. Reductionism is compatible with a traditional interpretation of objectivity where the aim is to minimise context, eg social and environmental factors, the 'noise' in the experiment. A holistic approach concerns the whole picture - in the example this would mean looking at the dynamics of the group of molecules and how this links with other groups or factors, which could include environmental and social issues, depending on the level of complexity. Holistic models and metaphors emphasise context and complexity.

There were two strands to the discussion. The first was the extent to which reductionism is the dominant approach in science, and how it varies across particular branches of science. The second issue was to what extent reductionism is masculine and holism feminine.

Reductionism was perceived to be the preferred approach in science, particularly the hard sciences.

> Science does tend to ... in the sense that it is reductionist, and tends towards mechanistic explanations, it is epistemologically loaded towards a particular narrow kind of interpretive framework. And I think that does tend to constrain people's thinking. (C1B)

Note there was a link made between reductionism and mechanistic models and metaphors.

In some sciences, for example astronomy, reductionism was considered a difficult ideal to achieve:

> The biggest difference between astronomy and other hard sciences is ... we have no ability to control our laboratory - it's basically out there and we can control how we measure it, but that's all we can control, and that's really fundamental if you're trying to do experimental physics ... so we don't really have the option of saying, 'well, we'll hold these other things constant and let this one vary', if we could we'd like to but as I'm saying I don't think you can understand the whole without understanding some of the pieces. (P9P)

A reductionist research design was seen as dependent upon manipulation of the research objects (eg holding certain variables constant whilst altering another). Note that a reductionist analysis was not considered to be dependent upon a reductionist research design: the data can still be treated in a reductionist way, eg searching for the dominant force as opposed to the complexity of interaction between variables.

Furthermore, as this excerpt suggests, holism and reductionism were not viewed inevitably as mutually exclusive. This could be considered to be like an hourglass - moving from a holism to reductionism back to holism. Note that a similar point is made in Chapter 7. One woman astronomer explained:

> There's an analogy both in philosophy and in science ... if you meditate on a point you meditate on something infinitely small in order to achieve something infinitely large ... and I don't think that one excludes the other ... that's a philosophical analogy. In physics there is a whole mathematical approach called a Fourier Transform which is essentially the same principle ... you transform it from one plane to another ... and I think that it's the same question in doing science, doing astronomy ... you want to hold down all the other variables so you can get this one because then, when you release the others, it tells you that one line out of the entire plane ... you need each line that makes up the plane ... I know I'm speaking in hand waving terms but to me it's just the same thing - I don't think you can just narrow down ... and somehow you are reductionist and missing the point ... you have to do that in order to get the bigger picture. (P9P)

The same interaction between holism and reductionism was stressed by others. This example is of physiology:

> [A female scientist] described the key to her success as [quote] 'a flair for discovery ... achieved most often by simple, straightforward experimentation backed up by good basic knowledge ... and perhaps more importantly by an intuitive feeling for the cells or tissues with which she was working' ... I'm not sure that isn't just a use of words, and that all of us, to be successful, can't sit back and be totally narrowly goal-oriented ... I don't think ... physiologists who are looking at ... isolated actions or tissues can be good physiologists unless they have this overall approach of linking the tissue to what's going on in the rest of the brain and the signaling from the tissue and organ up to the whole body and the whole body down to the tissue ... that's what physiology is about - it isn't biochemistry. (P1B)

The distinction between biochemistry and physiology is interesting - it may be that some sciences allow for more reductionism than others. Once more, note that research design, which is holistic, was still seen as constrained by reductionism. Consider another example of physiology research:

> The experiment that I'm doing right now involves people raising their arms very quickly and I'm looking at ... the muscles that are being activated during that movement. If I took a truly holistic approach to it I wouldn't even bring people into a situation where I told them to stand still and raise their arm. I don't think I could learn anything. I think I could wander around with electrodes attached to people and ... they would type and talk on the phone and I would never learn about the coordination ... so I honestly think that we have to constrain systems to a certain extent ... and so did Barbara McClintock ... she didn't just watch corn grow, she made crosses, she controlled the circumstances quite a bit. (P8B)

This suggests that reductionism and holism are not mutually exclusive. There is also different weighting between the two, depending on the type of science. Moreover, the perception of this weighting can vary within science - another woman had a different view of biochemistry as more holistic than indicated above:

> It's not true so much in my experience of biochemists [that they are reductionist] - biochemists have to take a more sophisticated and complex

> view of issues in their science ... and I think that chemists I know and physicists will look askance at that because they really prefer reductionist models, they want to know what is the one thing ... isolate the one issue that makes it tick. I'm much more conscious of trying not necessarily to always explain by one theory. (P19C)

In addition, there were indications that science is changing, and becoming less reductionist in some areas:

> Some areas of biology [are more holistic] ... like ecology ... at the ecosystem level, understanding functional and connected relationships. Other bits of biology are heavily reductionist, like biochemistry, and certainly genetics. Although ... I think there is evidence of changes a foot, and I think genetics is becoming ... not so much [more] holistic but less reductionist in the sense that there is now ... jumping genes and so on, there is a notion that it's much less rigidly deterministic. That's not to say that sociobiologists haven't produced some really crass theories about ... the gene for homosexuality. (C1B)

This challenge to reductionist methods is not just confined to the life sciences, although it is perhaps at it s strongest in this area:

> [Physics] is being done in a non-reductionist way ... there are big debates about that [between] condensed matter physicists and particle physics ... the argument about reductionism is alive and well in physics, although the overwhelming opinion, the received view ... is 88.8% [reductionism] ... it's very dear to the hearts of physicists for all kinds of historical, political and economic reasons. But more and more people have come to feel that the future of particle physics is limited ... and that's provided an incentive to think in less reductionist ways. (C5BP)

To summarise briefly, reductionism was viewed as the dominant paradigm in science, but it was argued that it cannot be considered as divorced from holism, as the two approaches are often complementary, or even in conflict, as the last example shows. The weighting of reductionism and holism was perceived to vary across different scientific disciplines and to vary within scientific disciplines, depending on the project. There were additional examples of a small shift towards more holistic methods in certain traditionally reductionist sciences - particle physics and molecular genetics for example.

Is reductionism masculine? Seventeen women explicitly made a link between reductionism, holism, and sex or gender. These links are similar, but differ in their configuration, especially around the issue of gender and sex. Only 3 women were prepared to argue that women were typically more holistic. For example:

> Well, I think this reductionist aspect ... slicing off these other things and saying they have nothing to do with science, which is something I don't really go for, that seems to be more common among men. (P14C)

The majority supplemented their responses, which indicated a link between masculinity and reductionism, with a more cautious analysis. This was based on arguments about socialisation of males and females, but there was a strong emphasis placed on the potential 'overlap' between the sexes and their approach, eg males taking a 'feminine', holistic approach in their science; and females taking 'masculine', reductionist approaches. The link was between reductionism and the cultural stereotype of masculinity not maleness:

> There is something culturally and stereotypically masculine about science, and the way it's thought of in our culture, and indeed the way it's done, the sort of macho behaviour in the lab ... which can alienate women more easily ... so maybe women have to face bigger hurdles to get to learn the way of thinking that is called scientific. I don't think that that's the prerogative of men - I think women can learn it just as easily [although] they might have more qualms about learning it. (C1B)

> I don't think my answer to that question was ever an essentialist one, that ... it's because women are biologically different therefore we just intrinsically do things differently, I don't think I ever believed that. But I feel more strongly and clearly now than I did then that this has to do with the fact that women and men really are so different because our socialisations are so different and that makes a difference. That doesn't mean that women who are trained in the standard ways of doing science and feel comfortable with those ways do science any different from the way men do it, and I think that some men have less reductionist ways of looking at things than others, and ... some women feel comfortable in the ... accepted reductionist framework. So I don't think it has to do with men and women, it has to do with a world view. (C2B)

> What we're talking about is the male role ... in North American and European culture one of the things that strikes me is ... if you have a class of people in a culture who are permitted to lead their own lives by being served by other people it will probably be more natural for them to be more narrow in other respects, to be more satisfied with a highly reductionist approach, and to see no need to do otherwise, so that for me what is being labelled as male is flowing out of the organisation of the culture ... [there is a] distinction between sex and gender. (P16C)

This 'world view' was seen to be shaped by gender socialisation not biological sex. There was also evidence that the challenges to reductionism in science do not always come from women - men in science may also becoming less reductionist:

> [Socialisation and training means] ... little boys [are] taking a part toy cars and little girls [are] getting used to the idea of focusing on the relationship between people ... I think there is still a tendency for people to grow up learning different sorts of skills and looking at the world [in a particular way]. I don't think that's absolute, I think it's changing - young men that I teach in class are much less rigid these days that I think they used to be. (PC4B)

Reasons for the women's affinity with holistic methods, and men's with reductionism, were attributed to the sexes' role in wider society.

Again, men's dominant role in this culture was seen to afford them a more reductionist viewpoint. This is, of course, one type of explanation among many. It could also be argued that men's reductionist approach is a result of their desire to control and manipulate - a holistic approach is much more 'in tune' with a less interventionist approach. Another argument was the following:

> I do think the models we use are sexist in their hierarchical nature and their omission of vital parts of human beings, because women identify more, and have identified more, with emotion ... leaving those things out of the way we talk about science helps to leave women out. (P8B)

This suggests that men are more reductionist and narrow minded because of their separation from emotion and feeling in their role in public domain. Women may be more 'holistic' because of the way their lives are organised which means they must cater for a range of emotional and physical tasks.

There were various other explanations for why women seem less comfortable with reductionism in science. The first example comes from a physiology teacher (who also gave the last quotation):

> I get to hear a lot of complaints about the way science is... students are very outspoken, and it's more of the women than the men who complain about reductionism ... in the sense of ... 'but in this study they didn't include ... how could they not include' ... and also ... I think this is a really critical filtering point for the students ... I think women more often have a hard time buying into the kinds of models that are taught in physics or in chemistry because they're so stripped down ... I think to some extent it has to do with men students' perception that this is their system, that in order to succeed in it all they have to do is stay on and believe ... I think the boys can buy into the system easier and ... go along on faith and then it will fill in for them, whereas for the women, or the girls, they will say, 'well, I don't see why they do that'. (P8B)

Women students being taught science appear to this teacher to be less willing to unconditionally accept the information provided. This is perhaps a product of their strangeness to the system - their 'outsider' status as women in a traditionally male domain gives them a more critical perspective than the 'insiders'.

Male scientists may also adopt reductionist strategies deliberately because they are more oriented to a successful career than women:

> There's this element of men thinking more carefully ... [and having] their eye to the main change and this applies to writing things up as well ... I said to a [male] colleague ... 'we've had this paper rejected because the chap, I assume it was a chap, couldn't cope with the fact that in the real life of the experiments there were some things that increased and some that decreased and he couldn't handle this variation' ... and he said, 'the authors haven't found out why this happens' ... there may be something in the way I wrote it up that wasn't good enough" ... [my colleague's] immediate reaction was, 'yes, well, I suggest that what you do is write up the results that go one way in one paper and get it published and then put the results that go the other way in another paper'. So you might interpret that as saying that women take a more holistic

> view and men focus on detail ... but you could also say that they have learnt good strategies for succeeding! ... I feel now ... at a pretty late age ... that I've learnt some of the strategies and am able to incorporate the conflicting results in the body of the paper and get it published. (P1B)

This theme of insider status of men and 'outsider within' status of women is carried on when other women talked about how this creates a more holistic perspective:

> I certainly myself have trouble with reductionism and objectification ... this is definitely an effect of gender ... I don't feel like I'm part of the establishment, I don't feel as if I'm accepted, I'm not treated as if I'm accepted, I feel uncomfortable ... and therefore because I'm marginalised I ... don't feel that I have to do everything that I'm told, so I don't feel like I have to belie my own experience and transform my own experience ... or my own perceptions about my own data ... I have a feeling it's probably to do with being marginal than being a woman. (P17B)

This woman scientist works in a non-traditional area of biological research, which combines biology, ergonomics and sociology to study occupational health. The work is also mainly funded by worker's organisations, and starts from the questions that workers themselves ask about their health, as opposed to questions that management or traditional scientists might ask. The work is therefore marginalised by fellow biologists in more traditional biology, who associate it with sociology, and therefore consider that it is not 'real science'. The relationship between this women's marginalised status and her non-traditional holistic research methods goes two ways. Part of the reason for her marginalisation is her research design, and part of the reason for her research design is her lack of association with traditional science, ie her marginalisation. This woman went on to argue that it might be that women are more comfortable with ambiguity in results and men more attuned towards certainty:

> I think there is something in the question of being comfortable with ambiguity that has to do with how women are brought up in our society ... I'll give you an example of when I was first classifying my yeast cultures I was supposed to classify them as resistant or sensitive to a particular toxin and I brought the plate to my supervisor and said, 'none of these are either resistant of sensitive, they're sort of all in between', and she said, although she was a woman, 'well, classify them all as resistant or sensitive otherwise we'll never get a paper out

> of this'. I think that its true that in science you learn to dichotomise, you learn to do away with the grey area in between. (P17B)

Despite the fact that this woman's supervisor was herself a woman she perceived their standpoints to be different, depending on their experience in science. This is related to the previous examples concerning holism, and some women's 'outsider within' positions affording them different perspectives.

Others noted that reductionist methods and models in science are also an attempt to find a clear and simple answer. They argued that scientists are aware that complexity is difficult to model and untidy models and theories are not publishable:

> If it can't be made into a model and be packaged up in a nice little [bundle] then it's not worth anything. (P14C)

> We're all affected by that - looking for what we expect to find. It takes a constant relooping and saying, 'OK, so I've proved myself right today, I'm going to prove myself wrong here' ... you alter it - you prove yourself right, you prove yourself wrong ... and it's so easy to go, 'oh, that's a nice graph. Call it a write up!' ... a big fat famous physicist makes a prediction and everyone thinks he's God and he's finally made it ... he said there were these vortex rays and everyone went and looked and looked and [one scientist] eventually found them, but they only had ... 0.3 ... like a salt shaker. I've been trying to tell them that's not right ... a lot of people are like that ... it's because he went looking for what he was expecting to find ... when he found it everyone thought, 'Ah, that's great.' They didn't think [he] could be wrong. It's easy to do that ... now they've done a little more experiments on this to see what happens with a 0.3% ... they've discovered that it ain't so ... The last conference I talked with the guy and he said, 'well, why don't you do the experiment yourself', and it's an extremely expensive experiment to do and he did it a long time ago and the results sit, they're quoted as canonical ... they're in text books everywhere. (P6P)

A similar example follows from another woman in the same group:

> This is a problem in atmospheric science as well. I'm ... looking at a regional transport model doing the chemistry part and I'm finding ... this area is very well funded compared to other areas but virtually all the funding is in the form of short term contracts that are targeted at a very specific problem ... and the whole area is a morass of grey literature ... and what you find are numbers out

of thin air, or you find a number that everyone seems to be quoting ... I met somebody at this conference and I said, 'OK, I've been trying to track this down', and she said, 'well, it's like this ... someone phoned me and asked what I thought this was and then the next thing I knew ... '. This was a number that's sort of part of the canon in atmospheric chemistry that has its origins in a casual phone call! (P14C)

This suggests that there is a tremendous pressure on scientists to come up with results (especially when they are on short term funding):

> You can't be wrong - that's part of the problem ... we have fostered a way of doing science that [means] you can't say outlandish things ... only when you get to be the crusty old professor and you're 70 and everyone around the world knows you and you have an impeccable reputation, then you can say anything you want ... if we started saying things that are a little beyond the pale, our careers would be over. (P9P)
>
> It's not just that, it's all the time - you have to publish so many papers a year and if you don't spend all your time doing things that you absolutely know inside out and have results, in other words, not new or creative things - you can't keep up that rate ... It's very damaging, and you say this to the gatekeepers, the people who are judging your hiring and promotion, and they just have no patience for it, they think it's a complaint from people who can't cope. (P10P)
>
> As I'm listening I'm thinking a lot of this is not gender specific, but I think what is different about it ... I'm going to go out on a limb here ... and say that I think women are more sensitive to the pain they feel, men I think, are trained to cope with pain - don't feel it, get in the back and take the next tackle - this is the way it is, you've got to do it. And it is painful ... my goal is to try to understand some things that are plaguing me ... and it's painful for me to watch this just dying on the vine while I go peddling away [writing papers]. (P11P)

Women's 'sensitivity to pain' may be more acute because of their 'outsider within' status in the scientific community.

The picture of reductionism and holism in science and how this is linked with gender is complex. There is clearly no simplistic association between women and holistic methods. Instead the data suggests reasons for women's limited use of holistic method that link methodology with scientists' status, marginalisation and their study area. This shall be discussed in more detail in Chapter 9.

8.3.5 Conclusion

There are two strands to my conclusions about interviewees' perspectives on control, topics and questions, objectivity and reductionism. The first is that generalisations about science involving particular approaches of control, objectivity and reductionism are problematic. Moreover, there is a vast array of different topics and questions raised in science. As I have shown, there are different contexts of control in science, which are not necessarily related to any meta-aim of control of nature. Similarly the role of objectivity in science also requires contextualisation. Science is clearly subjective, but the extent and type of subjectivity varies depending on the scientific discipline and the particular research practices. Finally reductionist methodology is not monolithic. Although perceived as the dominant paradigm, in opposition to holism, there are variations in the use of reductionism depending on different scientific disciplines. There is also an interaction between holism and reductionism - they are by no means mutually exclusive.

The second strand to my conclusion concerns the links between masculinity and science. Once more, there is no simple interpretation. There is no clear association between topics in science and the sex or gender of the scientist. Any differences that might arise from upbringing are blurred by the compromises women make to stay in science. Political sympathies, rather than gender, seem to guide a small minority of scientists into, or away from, various research topics. The vast majority, however, appear not be consciously political about their work, and are driven by a variety of reasons for working in particular areas, eg available funding. Links were drawn between male ego and suppression of emotion, and control, objectivity and reductionism. However, there was also a significant amount of material concerning rhetorical as opposed to literal associations between masculinity control, objectivity and reductionism. Different approaches by women and men in science were also related to their social status within science, in particular the extent of their marginalisation. This is discussed more fully in Chapter 9.

8.4 Changing Science

8.4.1 Changing the Scientific Community

The women I interviewed wanted to change many aspects of the scientific community. They wanted more flexible working patterns; a more collaborative style of interaction between scientists; changes in teaching to include social aspects of science; a more democratic science; changes in the hierarchical employment structure; more women in positions of power; and changes in the funding of science that would make science more consistent with feminist aims; and a more creative enterprise. There were a small number of comments about changing the place of science in academia. In a sense, earlier negative comments about the scientific community imply that these women would advocate changes whether they speak explicitly about such change or not.

In terms of lifestyle more flexibility was advocated. The following views were expressed:

> People should work more flexible hours - traditional marginalisation of women could end up enabling for feminist research - eg job sharing (P18P);

> There should be a cut in the number of hours people should work in the labs - the situation now stifles creativity (P2B);

> More flexible career paths and less time demands would benefit women (P9P, P10P, P11P);

More open ended careers and generous about people taking time out and having families is necessary (P13B).

For example:

> The way scientists work has to be altered, and this is very reflective of the way I think all society has to change. I think it has to have a more open ended entry to the career, so that people who are older than 30 and who've had delays in their careers ... should still be eligible to enter the field ... and I think that once scientists start to work they have to be more flexible in terms of the way they work. Right now the tenure system pretty much guarantees that during the first 5 years when you're on trial you have to toe the line to get tenure and that means you have to work full time, you have to limit any outside involvement you have in your community or in your family life, and you have to do things that will be publishable in acceptable journals, which will get funded, and which will get support from the department which ultimately decides your fate. If you spend 5 years doing these things so you get tenure it's hard for you then to open out again, you become locked into a career path, and so that has to change ... there also has to be a different acceptance of ways of working in terms of when you want to put your time into your career ... There should be a really generous approach in terms of people taking time out, or working part time ... I think these are very real impediments to women in science, and they're impediments to people maintaining connections with the outside community while they do science, and in this way scientists become isolated. (P13B)

The main emphasis is on change to a more collaborative style as opposed to a competitive one, and a more 'listening' and nurturing research environment. The following changes were advocated:

A more collaborative way of working (P19C, C6C, P16C, P2B);

A more collectively oriented way on interacting (P18P);

Less competition (P15B);

More open, less competitive interactions; more cooperative and open minded. A nurturing environment (P9P, P10P, P11P);

Scientists should be able to publish results that were failures (P14C);

A slower pace, not so competitive. Scientists should be allowed to report negative results (P8B).

Women also gave the following examples of how they had instigated such changes:

Team work is based on collaboration and constructive criticism. Egalitarian running of lab (P22B);

Provision of support networks for women in science departments; female role models, mentoring (P3P, P4P, P5P);

Running of lab collaboratively and encouragement of students (P15B);

Running of department on feminist principles - deal with women's difficulties as a supportive community (P17B);

Relationship with staff more supportive (C2B);

Interact with people more collaboratively. Increase awareness of women's status (P19C);

Work collaboratively - fostering cooperation (P8B).

Note that competition in science is not only between groups but amongst group members:

If they could just interact [in a] more open minded [way] and with more consideration for the people they're talking to, maybe they can still have their egos but do they have to be so critical? (P3P)

> I myself want more. I want to be able to work in a nurturing environment and I don't think there are many men who can fit in or provide that sort of environment ... I mean an environment where you can exchange ideas with people without fear of being judged, it's like working with friends ... I find women, if you want to talk about science with women, they're generally more supportive. (P4P)

Another woman expressed similar frustration:

> In terms of the scientific culture, well, there's a lot of things I would change ... one of them being ... this whole idea of competition ... not that competition isn't a good thing ... it's the idea that one always has to present oneself as being an expert and that one's own work is very good, it's the best, it's better than anyone else's work [that I reject]. I think, on the one hand, although people like to say that they encourage collaboration, on the other hand they like to put down other ... people's work ... I find that very discouraging. (P19C)

This is related to another comment about changing the restrictions placed on what counts as valid knowledge in science:

> I think I'd start almost with social relations of science if I could design science. It would be slower, not so competitive, when you got negative results, or you had doubts about what you were doing, or something didn't quite turn out ... you could report that and actually get it published, whereas now it's cut and dried. Meetings would be a lot more fun because people would be coming together to share ideas instead of to put one another down. (P8B)

Another interesting point concerns scientists collaborating with other academics. The following suggestions were made:

> Historians and sociologists should work with scientists (C5BP);

> Science departments should be organised like literature departments - with critics and practitioners (C3B);

> A feminist critique of science should be encouraged (C5BP);

One version might be:

> I'd also like to see science departments ... organised more the way our literature departments are. The English department, for example, has a component which consists of people who are actually creative writers, playwrights, and poets, but it also consists of a much larger part of people who are essentially literary critics - they have a period and genre that they study ... so they are critics of the products these other people are creating ... This is really an idea that Sandra Harding proposed with an exchange with me in print. What she suggests is that, and I think she's right about this, science departments don't work like that, they don't commune with [science critics], nor do they want to, they're actually hysterical about the science critics ... so one way I'd really like science to change is to have departments who were doing the enterprise and other people, who were sympathetic to the enterprise, but were also critically looking at it, in both historical and contemporary context. It would create a very different kind of teaching. (C3B)

The interaction of scientists and critics could also take other forms. However, the point is clearly made in this quotation - the critique of science as socially shaped is as important as the science itself.

This can also be communicated to the future generation of scientists via teaching. The following suggestions were given:

> Teaching scientists have to work to understand science is political (C2B);
>
> Science students should be taught about the social implications of science (P21P);
>
> An awareness of sexism into science curriculum (P16C).

Several of the respondents have organised such courses and encouragement of students. For example:

> Drawing attention to women in science, and different methods; emphasising problems unresolved and unaddressed (P18P);

Teaching courses which combine science with critique (C3B);

Mentoring (P10P);

Encouraging under confident women students (P15B);

Teaching courses on women and biology (P17B);

Teaching courses on feminism and biology; setting up open discussion groups (C2B);

A change in scientists' relationship to the community was another important issue. Consider the following proposals:

Less clear boundaries between people who do science and don't do science. Scientists are responsible for discussing their ideas in the community (PC4B);

Scientists should interact with community to promote a feminist science - science outside the lab (C1B);

Scientists have an obligation to communicate to the community what science is, and what science isn't. Scientists are part of community (P14C);

Break down the 'mystique' of science (P19C);

Challenge the alienation of women from science (C6C);

Science should be more accessible to people's democratic interests. Science should be more integrated with people - encourages more cross fertilisation of ideas and research projects (P13B);

> Examples - Involve community in research - eg a bird breeding or Carbon monoxide study where the public collected data (P18P);
>
> Example - patient involvement in health care decision making bodies (P13B);
>
> Example - Public-led research projects (P17B).

As we saw earlier a small number of women described the elitist role of the scientist in society. These women would like this to change and for the scientist to be more of an equal member of the community. For example:

> There would be less clear boundaries between the people that do science and the people that don't do science ... the scientists would have a very clear responsibility in discussing their ideas and their research and their processes with the larger community. (PC4B)

There is a feeling that there is obligation on the part of scientists to the public, as described by this woman:

> I feel we have a responsibility as a scientist to communicate, when I have the opportunity ... what science is, and what science isn't ... When I was working 20 years ago in the Maritimes reports were starting to come out [about the future of the cod fisheries] and the fisheries companies were putting up their own set of experts against these other experts ... at the time they won the day. To me that was a case of the people who were making the decisions for fisheries policy really not understanding what the nature of scientific investigation really was ... what was the nature of scientific proof. So I feel I have a responsibility to make it clear what science can say and what science cannot say. (P14C)

This responsibility is to provide the public with information about the pros and cons of science, not simply to provide so called scientific 'facts'.

In all of the three areas of employment, funding and publishing the women I spoke to advocated changes which would promote the place of women in science. The following suggestions were made:

Hierarchy and top down approach needs to change (C2B);

Science should be less hierarchical and open to people from different backgrounds (C3B);

Change the hierarchy to be more egalitarian with technicians etc (C1B);

Widen the types of people doing science; encourage multiculturalism (C2B)

Get more women into science - men in science need this to be better educated (P12P);

Get more women into science - develop a critical mass (PC4B);

Change the power structure - let women into science and powerful positions within science (P15B);

The whole tenure system has to change - it forces conservatism during assessment years (P13B);

Appoint more women (P16C, P3P, P5P, P7P);

Support projects that aren't necessarily high profile (P19C);

Also need to inquire into the behaviour of funding groups (P18P);

Change the granting system to collaborative research funding (P2B);

Change the structure of funding - not just about number of papers (P3P, P4P, P5P, P7P);

Develop longer term funding arrangements - to allow scientists not to be so focused on outcomes (P14C);

The funding organisations which study life problems should have representatives from people with experience of those life problems (P17B);

Science should become more decentralised - more room for diversity in scientific endeavor. Encourage diversification (P13B)

Politics of funding should be made more straightforward. Money should be made available for more creative science - so scientists can be less career oriented (P15B);

Feminists should support research which is consistent with equality of opportunity (P16C);

There should be more funding for science which would consider the environment, global poverty, medical research for men and women (P5P, P6P);

Example - Funding committees should include representatives of the general public. Breast Cancer Survivor's Group (P13B).

Note that this does not necessarily involve women's success on men's terms but could involve fundamentally restructuring the hierarchies in employment, publishing and funding. In relation to employment several women spoke about change, with 3 referring to promoting women into the power positions in science. The rest of the changes advocated concerned funding rather than publishing. Practitioners advocated more small scale grants and a decentralised, longer term approach to scientific questions with less emphasis on successful results but more on the process of doing science (which would presumably be reflected in journals and promotion). For example:

> [Science] has to somehow become more decentralised - so that there is room for more diversity in scientific endeavor - the tendency now is for it to become more centralised, to have large research teams, headed by eminent individuals who then sit on the journal's editorial boards and ... on the funding committee ... and so you have a kind of closing up of the varieties of endeavors that are being funded and published. Instead we need an opening of that kind of variety, we need a diversification. What this probably means is smaller grants to more people to do lower tech things (P13B)

One other women also suggested that the behaviour of funding, promotion and publishing bodies should themselves be studied (P18P).

8.4.2 Changing Research Practice

The main areas of change to research practice discussed by my interviewees were changes in topics of study and methodologies, specifically objectivity and reductionism/holism. However, as the previous section illustrates, discussion about changes in these areas also has implications for changes in the whole of research practice, as the processes are so interlinked. This is also related to change in the scientific community.

Changes called for in the topics of science were as follows:

Science should not be seen as separate from politics (C2B);

Multiculturalism would mean different questions were asked in science (C2B);

Women's view of the world should be included in science eg primatology (P1B);

There ought to be more diverse topics (P11P);

In biology there could be more respect for research subjects and objects - scientists should evaluate ethics of research (C2B);

No animal experimentation (C1B);

The ethics behind animal experimentation must be addressed (P17B);

Science should reject the manipulation of animals and make ethical considerations mandatory (P23B);

People should think more about the consequences of what they're doing in science (P20C);

Science should address all questions reductionist science has left out - interactive, multivariant, complex problems (P18P);

Proposed study of energy interaction with organic materials (P18P);

Example - Science arising from worker's own interests, not interests of researchers. Work in interdisciplinary teams with sociologists and biologists (P17B).

These changes fall into three broad areas: more diversity; more ethical considerations; and more non-reductionist questions. Diversity in topics was related to diversity in scientists:

> Being more respectful of other human beings and widening the number of people, the kinds of people, from which science are drawn ... would certainly change science. Now, that's certainly part of the feminist enterprise but it's not exclusive to the feminist enterprise ... the sorts of notions about multiculturalism that other people would bring other kinds of questions ... you

[also have to be] more careful that you don't use the need for expertise automatically to exclude other kinds of knowledge, the kinds of traditional knowledge that are certainly useful ways of looking at nature and explaining nature ... I think all of that needs to be included in what science should be like. (C2B)

The main ethical concerns were expressed about animal experimentation. One woman explained her growing disillusionment with animal experimentation, despite her love of biology, and interest in feminist research on sex difference. Her first research project concerned premenstrual tension:

> I changed my interpretation of what constitutes a feminist question, and, looking back into the seventies I now think I was being frightfully naive. Nonetheless it was as a feminist that I asked the questions. What I did for my PhD was stuff around hormones and behavioral changes with the oestrous cycle ... one of the things that was being much discussed at the time was premenstrual tension and whether or not there are behavioural changes in women with the menstrual cycle through hormones ... it was as a feminist with an interest in women's biology that I began to approach the question. (C1B)

The next feminist question this woman raised concerned Depo Provera - an injectable contraceptive mainly used in the developing world:

> And then I became more interested in the critique of biological determinism and I got more removed from that ... The next major topic that I started also started from a feminist project, but from a different place. I knew that Depo Provera was being injected into women throughout the world, even during lactation, and nobody knew what the effects would be ... So I set up a project which was going to look at the effects of oxyprogesterone, which is Depo Provera, on the development of young animals, rats, if it had been injected into the mother ... [to see if] it was getting through the milk. And it does, it has effects on their behaviour ... their physiology, their reproductive capacity. (C1B)

This led to a growing disillusionment with biological determinism:

> The next set of questions [I asked] as a radical biologist ... an antivivisectionist biologist. In a sense all of those [previous questions] were asking reductionist questions ... and I puzzled about how on earth I could move away from it. Then I started to think around the stuff about whether there are more than just

hormones involved in creating sex difference ... it's a big presumption in the literature on sex difference in animals that if you find a sex difference in a population it must be due to hormones, and there's lots of evidence, including some that we did, that shows that mothers discriminate, and what you get is an evolution and change of a social system. So I began to look at that, which, again, for me, is a set of radical questions, a more holistic way of looking at how alleged set differences develop rather than get determined. (C1B)

Finally, the issue of animal experimentation became paramount:

And then I finally stopped that, partly again because of the animal issue ... I was beginning to feel even more qualms at this point ... I wouldn't think a feminist science would accept the use of animal experiments as readily ... maybe we'd accept some, there might be something that we'd negotiate, but certainly not the way it's done now, large numbers of animals are used for sometimes relatively trivial questions and are not properly looked after. (C1B)

This story is interesting on two counts. First, it shows the variations in what feminist questions can be, depending on the evolution of feminist scientists' political beliefs. There is no static set of prescribed questions. Second, the ethics of research can be in tension with questions that feminists would like to explore. For example, an examination of the social component of animal sex difference tends to require some experimental work because of the difficulty in purely observational research in the natural environment. On the other hand, a feminist science might not always be anti-vivisectionist; in certain circumstances animal experimentation might be acceptable to feminist scientists.

The main area of discussion concerned objectivity and reductionism/holism (as we have seen above, this is also related to topics and questions in science). The following comments were made concerning objectivity:

Scientists should aim to be objective but be aware of subjective issues to aid them. Feminists should raise awareness of sexism so that people question their perceptions (P12P);

Science should accept and explore how subjectivities affect knowledge (P19C);

Scientists ought to reject the supposedly 'neutral' stance and admit subjectivities, but retain rules and critical discussion (PC4B);

An acknowledgment of ideas' social context ought to be part of the process of doing science (C3B);

Scientists must not lose nature in being aware of the social construction of scientific knowledge (P15B, C1B);

Science must aim for objectivity but acknowledge that ideas are socially generated (P1B);

Scientists could try to bring in subjectivities and awareness of assumptions into their practice of science (P15B);

Scientists should bring in emotion and should not ignore context (P17B);

Scientists should state their biases (P8B);

Science ought to be contextualised (P8B);

It is important that scientists position themselves in the research (P23B);

We need to make people aware of how their opinions affect science (P20C).

Interviewees favoured a retention of the aim of objectivity to eliminate subjectivities, but with more emphasis on thoroughly uncovering subjectivity. However they rejected the idea of separating knowledge from experience and politics. Instead these women argued for uncovering bias and subjectivities, in the sense of grounding knowledge back in experience. For example:

> I think there's different kinds of objectivity, and I think the objectivity that most of us were attacking is an objectivity that says I am nothing to do with this thing that I am studying and this great distance between this truth that's extracted from all human life and my ability to perceive what is going on, which is just sort of an empty screen ... a more honest approach is certainly to admit that we're involved in the process of knowing the world, so there's a subjectivity you necessarily bring to any kind of science, that you bring to the kinds of questions that you want to raise ... and for that matter ... to the process of getting sensitive answers ... now at the same time that doesn't mean there are no rules, no tests ... I think the whole process of testing and confirming and debating and investigating and comparing results is going to go on. (PC4B)

This is advocacy of a revamped version of objectivity rather than a total rejection.

Changes in the current reductionist framework in science were also very popular. Consider the following suggestions:

> Biology would be less reductionist if there was more concern for the ethics of research (C2B);
>
> Scientists should look at different factors impinging on behaviour of individuals (rather than just hormones) (C1B);
>
> Science should be properly contextualised in a multifactorial way - eg the discipline of ecology not biochemistry or genetics (although becoming less reductionist) (C1B);
>
> 'Master Molecule' theories should be rejected (C5BP);
>
> Scientists should try to take into account complexity (P2B);

More respect ought to be given for different types of explanations which are not traditionally considered as science (C2B);

Scientists must learn to listen to what the material is saying. However, they also have to constrain the system to a degree to get meaningful results (P8B);

Scientists ought to use the most suitable methods to get answers. This varies - so long as they are ethical - each method is valid (P12P;)

Reductionism and holism are both necessary - they just should not be over used (PC4B);

There is room for both reductionism and holism if answering questions properly (P13B);

The emphasis should be on prevention not cure - scientists should look at indicators to diseases, and put knowledge in its proper historical context (P13B);

More interdisciplinary work is necessary (P13B);

For example, research subjects could participate in research on energy interaction with organic materials - a non reductionist research design. Physics needs similar parameters to health research. Another example might be research subjects in mental health - patients participate at same level as doctors; or women's health subjects participating in research by keeping records (P18P) ;

Example - non-reductionist zoology research (P22B);

Example of feminist research into women's biology. Conflict about role of animal experimentation (C1B);

Example - the aim of science is to answer certain questions so take whatever tools are available; eg take more contextual view in example when looking at blood cells (P17B);

Example - holistic protein model (P19C);

Example - uses non reductionist methods (P17B);

Example - scientists should think more when applying standard procedures to data eg 'controlling for sex' (P17B).

A call for a more cautious use of reductionist approaches and more exploration of holistic approaches was made, with the proviso that the two should be complementary, and intermingled in some cases to produce the best tools for the job. Consider the following example of how this might change one particular research project:

> The one area that I've thought about working in this is the area of proteins and a protein model ... perhaps this is just one way of describing how one can present a different or alternative way of viewing ... one of the interesting things about proteins ... is that there's an assumption, a hypothesis, that the one dimensional structure of the proteins ... the amino acid sequence, determines what its 3-D shape will be, and its 3-D shape is directly related to its function ... there's been a lot of work in theory to try to predict what the 3-D shape of a protein will be given its amino acid sequence and the one thing that struck me was ... that you can predict just from the amino acids ... although its clear that proteins are stabilised ... by just a few kilocalories ... there's a lot of talk about what the dominant force that governs what the 3-D shape is and I think that's a really misguided approach, because it strikes me there's a real sensitive balance between a whole number of forces and that it's not possible to talk about a dominant force in that way. (P19C)

This more holistic and open approach to analysis also fits in with a more objective approach in the sense of openness about biases and influences.

An openness to different methods (the right tools for the job) can also mean the choice of a holistic approach:

> I think you want to find the answers to certain questions and therefore you take whatever tools are available in the field of biology ... and yet I know perfectly well in another part of my brain that we don't do things the same way ... when we look at blood cells, one of the things that we saw and that we criticised could have come straight out of Evelyn Fox Keller ... everybody was treating these genetic studies of blood cells as if they were sort of isolated from a human organ ... they were on petri dishes when in fact they were part of living systems that had certain interactions, and we've now published papers on this subject which is very different from what everybody else is publishing ... it's about a feeling for the organism ... so my data are contradicting my hypothesis ... so I guess this is why I'm feeling troubled about what is a feminist biology. (P17B)

Holism clearly plays a major role in these women's visions of a feminist science. However, we must also bear in mind that there are certain research topics and questions in science that are more suitable for a holistic treatment. Equally, holistic questions are not necessarily feminist.

8.4.3 Successes and Barriers

There is a large gulf between these women's ideal sciences and their description of science as it is now. Although some women have had limited success in changing the relations in their own sub-community of scientists and, to a lesser degree, their research practice, they perceived strong barriers to change.

Some women gave examples of how they run their lab along more egalitarian lines:

> I try to be cooperative and work collectively wherever possible. I work with a group of people, largely women, who share data and ideas in a constructive

> (often combative, but constructive!) atmosphere. We do have our egos, and must work hard to make the atmosphere work, but it does generally. Also my lab is run as egalitarianly as it can be, given that I have power over them. We concentrate on process and insist that people, whether male or female, listen to each other, make space for people's ideas etc, and allow each other to make mistakes and grow. (P22B)

Another woman was part of a department that works cooperatively:

> When you work with women ... you have to live with women's condition ... so we are having to deal with women's issues like pregnancy and day care and what do you do when the kids are sick ... we have battered wives ... and all of these things are part of our lives on a daily basis and because we're all women they become visible ... and have to be dealt with ... so in that sense a feminist approach is part of our daily lives. And we would feel like jerks, I suppose, if we did all this work on women's condition and the women that we worked with didn't profit from it. (P17B)

Several of the women I spoke to had also been involved in setting up and teaching courses on women's biology or incorporating a feminist critique into their teaching of biology. Others told of actively mentoring and encouraging female students. There was also one example of a move towards a more democratic science:

> We have here ... a special set up ... there are agreements between our university and three trade unions ... there's also another arrangement between the university and women's groups and both of those types of agreements provide that if the groups ask for research or activities then the University system will provide those sorts of activities ... So, for example, the first time that I was asked for in this way was when a health centre asked for a course in women's bodies instead of giving four or five hours of regular teaching of undergraduates ... I've also been quite involved with women's groups, particularly in the trade unions, and particularly around issues of women and work. What I've noticed is that the questions that women ask are not readily covered by existing research projects. (P17B)

This type of client participation in scientific funding and research projects more generally is one way in which ordinary women (and men) could have an input into science that was relevant to their lives. This would obviously alter research topic and questions, ie research practice. In particular, this would lead to less reductionist science.

More space for holistic approaches appears to exist in the biological sciences, and 3 of the women I spoke to gave examples of how they have taken holism into their work in biology, for example a zoologist states:

> My science is not controlling. I allow pieces of the nervous system to interact freely. This is hard, because one doesn't know who is doing what and the methods for discussing and analysing the data must be completely different. The language I use is also completely different. It utilises the language of feminist processes, namely, consensus among the parts, where the parts are equal, there being no controlling elements. The brain, for example, is then viewed not as being at the "top" but as being simply another part ... the behaviour of the "system" emerges from the parts coming [together, to] consensus. (P22B)

Interestingly, this type of holistic approach occurs in a laboratory run collaboratively (see above quote).

Nevertheless, the processes involved in changing the wider scientific community are daunting. The most obvious starting point for a discussion about changing the culture of science is the problem of treating scientific culture in isolation from the wider culture. When one accepts instead that the culture of science and the wider culture are closely intertwined, the project of changing the culture of science becomes a project to change all male dominated culture. One woman expressed this clearly:

> I think it's very hard to expect scientists to be way ahead of their culture on this. The rest of the culture will have to be more respectful of other ways of looking at things before scientists are likely to do that. Scientists are ordinary people and they're ... pretty elitist people, they're people who've had a lot of education and are by in large privileged people and that they would trade some of this privilege any more than other people who are in business or in law seems unreasonable. I think we're talking about major social changes. (C2B)

It is this level of immense 'technical, cultural and cognitive inertia' (C5BP) that prevents change.

More specifically, there remains a difficulty in envisaging a feminist research practice in physics (as experienced by 5 of the interviewees). Nearly all of the examples of change involve the biological sciences. Only one woman talked about a feminist physics - giving the example of research on the interaction of radiation with organic materials (P18P). However, this research still involved human subjects and is seen by others as 'not really physics' (P4P, P5P).

There was little discussion of how physical research involving inanimate objects could be made more feminist (barring the example from theoretical chemistry). This can be imagined as happening indirectly - changes in the scientific community would involve the physics community, and have implications for research practice. However, it is easier to construct and imagine a feminist biology. This requires further investigation (see Chapter 9).

The project of getting more women into science also requires immense changes to promote more women as well as changes in the gender ideology of science and society at large. With the increasing numbers of women leaving science as they move up the hierarchy feminist face an uphill struggle (P18P). This is a slow and tedious process - only women who have reached the top are in a position to successfully mentor other women (and feminists) (P18P). Middle and lower ranking women are pressured to remain silent and uncritical (for fear of losing the support of their male colleagues, or, ultimately, their post) (C3B). The present funding squeeze in the US has also resulted in the cut back of affirmative action programs, which are casualties of the general low level in recruitment (P16C).

More women in science was clearly viewed as fundamental to any consideration of a feminist science. Others argued that feminists must also seek to win over the support of hostile scientists, especially women (as noted by C5BP, C6C), by challenging their vested interests in denying the link between social relations and science (C3B). There is undoubtedly a backlash against scientists who question the traditional notion of objectivity. This appears to be because such a suggestion threatens the existing power base of scientists, which relies heavily on their privileged, supposedly neutral, position (C2B). Bringing in the idea of subjectivity and suggesting that male and female or black and white scientists will do science differently is also rejected by a lot of women and black scientists (C5BP, P2B). This appears to be because they feel this can be used to disempower them further in science (see student data Chapter 7).

There are also many barriers to change in the funding of science, not least because of the structural hierarchies in all of society. The military-industrial complex links science and capitalism primarily through funding and commissioning research. This is undoubtedly an important driving force behind the emphasis on publishing of new (and coherent) results. These research projects must also be of value to the capitalist enterprise. The present funding cut backs make the competition for awards more ruthless and limits the types of projects receiving funding. The importance of such a relationship cannot be underestimated as it plays a powerful role in the maintenance of the existing structures in science (P18P, C2B).

Changes on a more modest scale are also difficult to achieve. Science departments are generally hostile to unusual approaches to science, or involving politics in science courses. Women scientists who are feminists find it difficult to succeed in science and are unable to 'come out' as feminists until they have secured permanent positions in science (C2B, P18P, C3B). This is a long process and can mean, as we saw earlier, that women either become disillusioned and leave, or change their politics to survive. As one woman argued, it will take generations to affect any real change in the numbers of women in science (P21P), let alone the numbers of feminists.

Only 3 of the women I spoke to felt that they have been able to study feminist research topics in science - these include studies of female hormones (C1B) (see above) and more applied research on women's health (P16C). However, this research is very rare and often at the expense of a successful career in science, if it does not fit in with established ideas, as illustrated in the case of one woman in particular (C1B). Two others also discussed trying to adopt new standards of objectivity in science, by thinking about a research problem in its social context (C3B, P8B). The extent to which this new approach to objectivity is possible in science as it is at present is limited. Both these issues of topic and objectivity are linked, as the following comment illustrates:

> Well I do [apply redefined objectivity] in the sense that I study the social context out of which the question has arisen and I know about its history, I know about how these ideas have come to be ... [and where] my ideas are situated in regards to ... the mainstream ideas, ones that are further out than mine, what I'm manoeuvering through ... but I'm a lonely person I don't have much ... money ... so its a little bit different from ... if I were negotiating through the NIH [National Institutes of Health, USA] or something like that. (C3B)

Clearly, the existing practices in science do not allow for such unorthodox approaches on anything other than a very small scale, and women find instead that, although they get to think about these issues and maybe even talk to other like minded people about them, securing funding or finding a venue to publish (the most significant medium of scientific knowledge) is difficult.

In the case of holism, as we saw earlier, it is not always possible or desirable in all of science (C1B, P19C, P13B). For example:

> Sometimes it would be a different tool that would be used, and a different question that would be asked to get at the same problem ... looking at breast cancer ... Rather than looking at whether radiotherapy or chemotherapy are more effective at different stages of disease, maybe you do a very reductionist analysis of which population is exposed to which chemicals and carrying which body fat proportions have been ... most afflicted with breast cancer so that's still a reductionist approach but it's asking very different questions, it's asking

> why do we get breast cancer rather than what do we do once we've got it. (P13B)

In this case the research design was reductionist, but feminist questions were asked.

8.4.3 Conclusion

For these women changing science meant changing the social relations of science in terms of interaction between scientists, interaction between scientists and the wider society, and research practice. More flexibility in work patterns, diversity, collaboration, democratisation, ethical considerations, decentralisation, and grounding of knowledge in experience and context were all advocated. Although some examples of change on a local level were given, it was recognised that changes on a more wide scale level are hampered by discrimination, 'cultural inertia', including hostility amongst scientists to change, funding cutbacks, and the links between science and the capitalist economy more generally. Even on a more modest scale most other scientists were experienced by interviewees as suspicious of political involvement amongst their peers, and resistant to new methods of teaching and research.

However, the situation is not all gloomy. Just as many of the women I spoke to would like science to become more flexible, they were also flexible about how science could change. There was no one particular methodology advocated (eg holism); instead there was a desire to see a more creative use of different methodologies, including reductionism, where this was appropriate to the research questions. Moreover, as changes in the community and content of science are interlinked, modest changes at one level can be expected to have repercussions at the other, eg change to a more collaborative style of working would in turn alter the research practice. Significantly, there was no rejection of science being based on empirical findings, which means that, in this respect, change would be continuous with existing research practices.

I now move on to consider the practitioners' responses to feminist epistemologies and theories of science. I am interested in whether feminist epistemologies and theories reflect the criteria for change detailed above, and if and how they are a useful resource for women in science.

8.5 Feminist Epistemology and Theory

8.5.1 Responses to Feminist Epistemologies

This section deals with the women scientists' responses to feminist epistemology and theory about science. Women's views are related to their familiarity with the literature. There were a substantial number of women - 11 - who were unfamiliar with the majority, or all, of this literature. A typical position was the following:

> I guess I'm pretty much unfamiliar [with the feminist epistemologies]. I would classify myself as a strong feminist in the sense that I believe in equal opportunities and I'm beginning increasingly to see the need for some positive effort to help women achieve those equal opportunities, but I'm very badly read in feminist books, and I'm only beginning to read some, the odd book by Hilary Rose ... so I'm beginning to understand what the feminists in science are saying ... I don't see an application for that in my particular subject. (P1B)

This also meant that the majority of this group (8) were perplexed about what a feminist science meant, as they associated science with objectivity, a feminist science was therefore an 'oxymoron' (P24B), particularly in the hard sciences, for example:

> The idea of a feminist physics ... it's ... impossible ... I think feminist science is a misnomer. I think the core of science is ... there is no gender ... I think it's a few levels up, at policy, decision making ... that says what kinds of problems we want to solve and what kinds of experiments we do as humans ... I think it's a misnomer in science itself, I don't think it's a misnomer in science education. (P21P)

This illustrates a profound gap between these women's experiences of feminism (or their promotion of women in science without the feminist label) and feminist philosophers and theorists of science.

Their more detailed responses were therefore based around my descriptions of various feminist epistemologies, also used in the student interviews detailed in Chapter 7. It turned out that their views were very similar to those expressed by the students. Again, the majority of this group favoured an epistemological approach that tried to be objective, by uncovering bias, but did not involve the privileging of any particular perspective, and all advocated getting more women into science as an important step in eliminating bias. There was also an acknowledgment that scientific knowledge is affected by subjectivities, and that these should be made explicit.

The others (19) were more familiar with the feminist theories and epistemologies of science (if not with individual theorists, at least with the general concepts and debates in this area). These women were critical of feminist epistemologies and theories. Several mentioned their discomfort at the problem with essentialism in some of the theories.

This is worth mentioning as it may give an important insight into the ambivalence, and/or hostility, of other women scientists to the project of a feminist science. The idea that women do science differently, as argued earlier, can act to disempower women in science because marking them as different from the majority (men) might be equated with marking them as inferior. Some were also uncomfortable with the label and concept of a 'feminist science', and, for example, argued instead for a feminist critique of science (C3B, C5BP). Finally, the emphasis on feminist epistemology in feminist criticism of science was seen by another small group as somewhat misguided. For example:

> I don't care [about feminist theories in some ways], that's another issue ... I read articles ... there's a whole issue about whether women think differently than men, whether they act differently, and whether there's a feminist way, and

somehow I think I don't care, I want to be able to do science and I want other women to be able to do science - I don't think they have to do it like me ... it's not important to me ... defining it doesn't seem to me a useful way of doing it, or changing the situation of women ... it doesn't seem productive, even if it's possible, which I doubt. (P11P)

Nine of these women also made more general comments on this apparent gulf between philosophers and social scientists on the one hand, and natural scientists on the other. The strongest view was the following:

> I think you must be enormously aware of the problem of disciplinary division, of the Grand Canyon across which one has to shout when one tries to communicate between the natural and social sciences, and on the one hand I'm fascinated by this area in which you're studying, and on the other hand I'm enormously frustrated by what I see as ... a superficial approach on the part of my social science colleagues who have no understanding of science ... I hear science is awful because it's competitive and hierarchical, and it's taken out of context, and there are many respects in which I agree those are probably issues ... but I think it's time we moved beyond those labels and started asking really serious questions and doing the research to go beyond that. (P16C)

Other women made similar, if less forceful, comments:

> In conversation I feel that people from the outside when they criticise science ... they often criticise ... from political points of view ... 'how nasty it is to think like this', or, 'how contemptuous it is to look at women in this way', but they don't pick up on the methodological areas, which is completely understandable, but some people will spend a lot of effort denouncing a scientific piece of work without realising that it is also erroneous, so the time shouldn't even be wasted on whether it's nice or not ... because it's just wrong. (P17B)

There appear to be two strands to these women's criticisms: the first is that the critics of science in Philosophy/Social Science/Women's Studies do not always understand science, and the second is that they are not always sympathetic to science, and that these qualities are necessary for an effective critique of science. There are also empiricist overtones in this type of response, ie a belief in the ability to evaluate the errors in science.

One woman argued that the different feminist epistemologies can be used, selectively in different contexts (of discussions with scientists):

> Well I think one uses them all in different contexts. I become a feminist empiricist when I'm dealing with some, yet another round of crap, for want of a better word ... there was a book a couple of years ago ... about the brain ... and sex difference and it was just appalling ... 'feminists have got it all wrong and misled everyone else ... and there really are huge differences in the brain' ... And so when I'm dealing with people like that I think one has to be a feminist empiricist, has to stand up and say, 'but there is scientific evidence against this, and what we really need is a more true science', and I say it tongue in cheek . (C1B)
>
> What about standpoint theory? (AK)
>
> I think that it's got it's usefulness, I think that I wouldn't be a feminist if I didn't believe that women had some degree of commonality ... otherwise ... there is no physical grounds for feminism at all. And I think that's important, and it's important for me as a lesbian, but that's not to deny there aren't important differences [amongst women] too. Standpoint is also important in relationship to the way I think about animals ... a lot of postmodernist writing ... it's all fracturing of identities ... within the human realm, so that nature remains some sort of fixity, some sort of other to which we are opposed ... then it rests paradoxically on a kind of standpoint, a human standpoint. (C1B)

This woman also argued that the place of nature in feminist epistemology required negotiation:

> We actually have a neat way of supporting biological determinism while we support social constructivism ... we deny any biological [component] to [the behaviour of humans] ... we'd say social construction, right? We don't mind admitting that we have ovaries which secrete hormones, or our bodies are biological, they're biologically constructed, so we keep that dichotomy [between the natural and social]. When we talk about animals, if we do it at all, then animals, of course, are purely biological ... So, given that there will always be a ... cross fertilisation ... between how we see human societies and how we see animal societies ... there will always be someone who will make that jump ... it's going to generate biologically determinist hypotheses. What we should be doing, to counteract that is to say, 'but we shouldn't be biologically determinist about animals either, who says it is all down to their hormones? Why can't they have a social and biological interaction? Who defines what biology in the first place?' (C1B)

There are two tensions in the feminist science theories illustrated by these comments. The first is a tension between the natural and the social, which includes a tension between empirical evidence and social construction of evidence, and that between animals and humans. A second issue of difference amongst women and commonality also arises. These will be explored further in Chapter 9.

More specifically, other comments illustrated the problem with 'translating' from feminist epistemology and theory into scientific practice. One example concerns a revamped notion of objectivity, promoted by Harding and referred to as 'strong objectivity':

> Oh [ideas about strong objectivity] are probably not practical ... I don't know that people are necessarily capable of being open about their biases, or to know what their assumptions about the world are all the time. Sometimes you know and you can lay them out, one, two, three, four, five ... but often you don't really know until you're confronted by something that is different from you or antagonistic to you. (PC4B)

Another scientist turned feminist critic also made a similar point about Donna Haraway's 'situated knowledge':

> I really like Donna's paper on situated knowledge very much ... it's not so far from my own thinking about perspectival accounts of scientific knowledge ... but ... these are not concepts that would be operative ... in the work of science ... how would you translate that? What kinds of questions would you ask ... I laid out ... 3 levels of concern ... the questions one asks, the methodologies one employs and the explanations one finds ... try to translate situated knowledge into the questions one asks or the methods one employs ... maybe it would be easier in terms of the explanations one finds satisfying but let's have some examples ... what would a situated knowledge question in the development of biology ... I have ideas about how to approach ... the kinds of questions I would like to see, the kinds of methodologies, the kinds of explanations ... they're not unsympathetic with some of the things Donna has argued, but the notion of situated knowledge, I wouldn't begin to know how to translate it. (C5BP)

This gap between theory and practice is very real for those scientists and critics who are familiar, with the feminist epistemologies, as well as those who are unfamiliar. This suggests that it is more appropriate to question the theoretical premise of feminist epistemologies, rather than the understanding of feminist and women scientists.

There is also the issue of the lack of social mechanisms to support a feminist epistemology:

> I don't think [the feminist standpoint theories are practical] ... that's the short answer ... obviously there is a very simple [interpretation] if we allow that women might bring different life experiences [into science] then anything which opens up science more to women would make that possible, with in the kind of general, broad remit of standpoint theory. But we don't have the crèches ... we don't open it up ... to women specifically in that kind of way. There are more women in science than there used to be but they do have huge problems. (C1B)

Changes in the organisation of science are clearly seen as preliminary to epistemological change.

However, this discontent does not totally invalidate the project of a feminist epistemology of science, as 11 of the women I spoke to argued. It was pointed out that feminist epistemology should not be used as a blueprint for a feminist science, but more as a 'mirror to reflect against' (P10P), for women who are in science. The role of some of the theories is therefore to 'push the discussion' around feminism and science. For example, one woman talked about Donna Haraway's work:

> She's wild and woolly isn't she ... it's visionary ... I've gotten to the point where I can enjoy it, that was a good step. A student of mine said, 'read it as if it's performance art, as if she's just standing up and spouting this stuff off', I get that, it's a real trip ... save the world through cyborgs, I doubt it, it's not my predilection, but it's wonderful to see, it's performance art to me, I can appreciate it, I don't therefore think I'm going to do it. (P8B)

Of course, some of the theories are more at the 'performance art' end of the spectrum than others. One comment concerned a fundamental difference in the aims of these different theories:

> Well they don't all call for things to be put into practice. I would say ... the philosophers ... are probably more focused on scientific practice for the future and Donna [Haraway] more on analysing scientific practice, although if you take her analysis and if people doing science started to think analytically in the way she does that probably would change their practice. (C3B)

Moreover, not all of the women felt that the difference between philosophies and theories has to do with training as a scientist, but depended on understanding and sympathy for science, as noted earlier:

> There are two parts where one deals with the activity of being involved in science. One is doing science, in actual fact, doing measurement in the lab ... and one is understanding science, that is really being able to understand the meaning of the scientific result, of the new fact, of the new observation, in the narrow and in the broad sense. Now these two things are in many ways separate strands. There are some people who are excellent scientists and don't understand science at all ... in its impact. ... There are a lot of people who are among the very good science writers and the odd scientist who both does science and understands it ... but when you go to people ... who are philosophers you have to look at what sort of understanding they have. The very fact that they aren't working in the lab doesn't disqualify them, just as the fact that many people in the lab couldn't write two paragraphs about the philosophy of science. (P18P)

8.5.2 Conclusion

It appears that feminist epistemologies are not a good match with the expectations and aspirations for change expressed in section 8.4. There was ambiguity about what a feminist science means and about its utility. A lack of communication between scientists and theorists may be a reason for this gulf. There was a feeling that feminist theories need to be more sympathetic and understanding of the scientific endeavor.

Tensions in the feminist epistemologies between commonality and difference amongst women and between the social and the natural realm are evident in this data. Problems of 'translation' from theory into practice are also highlighted. Questions were raised about the mechanisms for the expression of subjectivities and the kinds of questions a feminist science would explore. Social changes necessary to achieve a feminist science were also discussed. This has implications for all of the feminist epistemologies of science.

Despite these problems the feminist epistemologies were perceived by some as playing an important role in stimulating thought and debate. The temptation to amalgamate all of the theories together must therefore also be avoided - some are more focused on practical change than others. There are many differences between the feminist theories that this section has not explored fully. I conduct such an exploration in the following chapter.

8.6 Conclusion

With respect to how science is gendered in practice, considering the role of social relations in the scientific community and research practice, the practitioners' experiences confirm that the lifestyle of scientists, their networking and styles of collaboration, in addition to their interaction with students and the wider community, and the hierarchy of promotion, funding and publication, are all interdependent, and shape scientific knowledge. I illustrated an association between scientific practice and characteristics of competitiveness, confrontation and hierarchy - all stereotypically masculine. A scientific career is clearly more conducive to an archetypal masculine lifestyle and style of interaction.

The structure of employment in science is hierarchical; and male domination is perpetuated by the hiring and promotion system where 'like favours like', ie men favour similar men. Funding also goes to big projects and big research; prompting a high level of competition and the funded elite at the expense of smaller projects. The data suggests that women are disadvantaged via the structure of science, because the 'cloning' of those at the top of the funding and promotion hierarchies tends to exclude women.

The data illustrates how the social relations in the scientific community that affect the content of science can be gendered. These include a more critical approach to women's work and marginalisation of women who do not communicate using the dominant style. Both criticism and marginalisation affect the influence of these women on the content of science. Competition and confrontational interactions, which I have identified as stereotypically masculine, also affect scientific knowledge. Other social factors that heavily influence the content of science are external pressures from funding bodies, and internal pressures from the scientific community, which prescribe the topics to be studied, and shape the frequency and results of research because of the pressure for new, coherent and useful information. These social relations act to limit the opportunities available to women scientists, in contrast to their male peers. More generally, the practice of science is shaped by wider political and economic considerations.

Research practice and gender relations are more difficult to model. The data shows that there is no monolithic research practice. Instead I found the aim of control, levels of subjectivities and use of reductionism, varied in different contexts of scientific practice. Although some women argued that these are tied to deep rooted masculine traits, others identified a rhetorical, as opposed to literal, association between masculinity and control, objectivity and reductionism. Different approaches by women and men in science were also related to their social status within science, in particular to the extent of their marginalisation. For example, women's position on the margins of their community may allow them to pursue more unorthodox approaches. This is another example of the interaction between the scientific community and scientific content. However, this relationship can also be mutually reinforcing in such a way as to suppress unorthodox approaches and the promotion of women in science.

I intend to use this empirical material, on how the practice of science is gendered, to inform my discussion and analysis in the following chapter. The main goal of my research is to suggest a practical framework for a feminist science. I have stressed that a fuller understanding of how science is gendered is necessary before such a framework can be constructed. What does the data mean in the context of achieving a feminist science? What are the likely starting points and strategies for working towards a more feminist science? What are the obstacles and how might they be overcome? The answers to these questions will be explored in Chapter 9.

The second important aspect of practitioners' experiences and views concern changing science more directly; it dealt with interviewees' aspirations and expectations of change and reactions to feminist epistemologies. Practitioners advocated a change to a more supportive environment in science; a better position for women in the structure of science (this may mean changing the structure); a more equal and democratic distribution of funding; and a more equal place in the community. In research practice, more social responsibility and the opening up of the process of scientific investigation to explore bias and context was favoured. The goal of objectivity was not entirely rejected; making subjectivities explicit was important precisely because it provided scientists with the opportunity for a more impartial evaluation of scientific results.

I found that such changes in scientific practice have been achieved on a limited scale, by individual women scientists, working on small projects, or by groups of women scientists who have formed their own networks. However, the barriers to larger change are strong and complex. The data suggests there is an inertia to change in science. Scientists have a vested interest in maintaining their position of power in science, and therefore contribute to this inertia. Moreover, the scientific culture does not exist in isolation from the wider culture, for example the importance of funding in science cannot be underestimated, and any massive changes in science require, and may even have to be set off by, a corresponding change in wider society. The implications for a feminist science of this information require further investigation. There is a need to identify the barriers to change and consider positive strategies.

The feminist epistemologies do not entirely match with practitioners' vision of an 'ideal science'. The reasons for this mismatch may be related to the isolation of academic subjects such as philosophy, social science, and women's studies, from the natural sciences. This can create a gap in understanding and sympathy for science, which in turn can create unreliable analyses of science. However, for balance, it was also noted that there is nothing to guarantee understanding of science inherent in being a scientist, as many scientists do not seem to have an understanding of what it is they do, in the broader sociological sense. Furthermore, there is also a role for epistemologies, not as blue prints for practice but as mirrors for reflection for scientists, to develop the discussion about feminism, gender and science. However, the problem seems to be that such a mirror is not accessible to the majority of women in science and the technique required to use the mirror are often alien to women and feminists working as scientists.

A proper evaluation of the different epistemologies is still necessary, and will be conducted in Chapter 9. The tensions in the theories - between the natural and the social realm, and commonality and difference amongst women; in addition to problems of translation - require further exploration. This will be derived from the data on how science is gendered in practice, and on women scientists' aspirations, expectations and strategies for changing science.

Part 3 Synthesis of Theory and Empirical Material

Chapter 9 Discussion and Analysis

9.1 Introduction

My main aim in this thesis is to suggest a practical framework for a feminist science. The first step in this process is to acquire an understanding of how the practice of science is gendered. The second step involves developing the concept of a feminist science in relation to scientific practice. And the third step involves exploring practical strategies for change. Here the theoretical analysis in Part 1 is combined with data on the experiences and perceptions of science students and feminist practitioners from Part 2, in order to address these aims. In synthesising theory and data, I aim to provide a more robust analysis of the relationship between gender, feminism and science than that offered by theory or data alone.

My treatment of interviewees' recollections and perceptions reflects my own concerns about the relationship between masculinity and science and the possibilities for a feminist science. I do not uncritically adopt interviewees' comments about gender, feminism and science, but choose instead to deconstruct responses, looking for contradictions and comparisons. I focus in particular on concrete examples and places where respondents, especially women, spoke about their ambivalent position in science. My concern to uncover the complexity of the practice of science leads me to focus on variations in practice, especially differences in practice because of subject matter and research questions.

First, in section 9.2, I consider how the practice of science is gendered. I address the male domination of science and the ways in which gender influences science more broadly, looking at how it shapes choice of research methods and scientific knowledge. I am especially interested in interviewees' perception of the relationship between gender and scientists' actions and rhetoric. I explore social relations in the scientific community and in scientific methodology, highlighting variations in practice in different contexts. I then discuss how characterising science as a male domain might be a useful way of understanding the relationship between gender and science.

In section 9.3 I combine a consideration of interviewees' suggestions for changing science with the notion of science as a male domain. I address questions raised by my earlier critique of the feminist epistemologies of science and suggest a 'best version' of a feminist science - ie a workable version of a feminist science which can be promoted from within the existing scientific institutions, but does not forfeit a commitment to radical change in the process. I explore what constitutes the 'best' kind of feminist scientists; feminist questions and methodology or methodologies; organisation of a feminist science; and the relationship between a feminist science and the wider society.

The next section, 9.4, concerns strategies for achieving this best version of a feminist science. I emphasise the importance of integrating three key strategies: getting more women into science; feminising scientific methodology; and challenging the organisation of science. The dialectical process of change within the scientific community and outside, in the wider society, is also highlighted. This includes an exploration of some first steps for change. I then consider how a feminist science might be taught.

9.2 Gender Relations in Science

9.2.1 Male Domination

The practitioner data on women's place in the scientific community, outlined in Chapter 8, is a detailed exploration of the male domination of science, introduced in Chapter 2. Women reported finding it difficult to fit into the typical lifestyle of the scientist. Interviewees felt that male scientists dominate the important networks of communication, hold the powerful positions within science, and deliberately or inadvertently favour other male scientists and students. These male 'invisible colleges' (see section 3.3) appear to provide essential channels for promotion of male scientists and their work. The empirical material also enhances understanding of women's attempts at assimilation into science. As described in Chapter 8, women scientists may adopt so called 'masculine' behaviour and some enjoy successes equivalent to their male colleagues. However, adoption does not necessarily guarantee success, and such women may be penalised for displaying 'uncharacteristic' gender behaviour. Other women are marginalised from the important areas of science, which tend to be more male dominated. The situation is especially bad for feminists who are often penalised for bringing politics into the supposedly neutral realm of scientific research and teaching.

The material gained from interviews with students further illustrates the taboo nature of politics in science, and how this is instilled via science education. Moreover, students tended to resist suggestions that science was influenced by sex or gender (note that no clear distinction is made by students between sex and gender), on the basis that such suggestions compromise the integrity of the scientific method. I believe that female students tended to be more dismissive of suggestions that sex and gender influence science than male students because they associated such suggestions with sexism, and therefore perceived them as a threat to their position in science. Their position is similar to women scientists seeking to conform to the accepted protocol of science as outlined in Keller's analysis of women scientists' hostility to feminism (see section 3.6).

The data in Chapter 8 also supports the concept of institutional norms, conventions, barriers and invisible colleges in science, from the sociology of science (section 3.3), bringing sex and gender into the analysis. For example, the notion of gatekeepers, who 'clone' future generations of scientists, was described by some practitioner interviewees. This process of replication was also implied in students' adherence to an overtly empiricist characterisation of science.[27] Women respondents suggested gatekeepers tended to be male, and to 'clone' other male scientists in their images. Patriarchy - male rule, traditionally passed from father to son - is therefore involved in the institutional processes of science. Scientists' general resistance to new approaches, and entrenched vested interest in continued success, which involves denial of the political and social content of science, was seen by some interviewees as leading to discrimination against women in science, especially feminists who are experienced as a threat to the established conventions in science. From the data presented in Chapter 8, I would argue that this is certainly true in the case of scientists with feminist sympathies who seek to challenge the 'old boys' network'. Perhaps women scientists also have less to lose by breaking with convention, considering that their marginalisation from important scientific areas and centres of power might already be established or imminent. Other women, who might not actually be a threat to convention, can also find themselves marginalised. I suggest that marginalisation occurs because they are perceived as a threat by their male colleagues, precisely because they are *female* and expected to be at odds with a system which so blatantly favours men. The forceful denial of sex and gender influences on science, particularly by female students, might be a strategy adopted by some women to deflect male scientists' perception of them as a threat.

The interview material demonstrates that these types of social relations in science cannot be divorced from scientific knowledge, even though this is an implicit notion in much of the feminist literature detailed in Chapter 2 and in many of the students' and a minority of practitioners' responses. Women felt that their work is more closely scrutinised because they are perceived as less confident by their male colleagues. Women have been side-lined in groups and their contributions ignored. Those women who are less ambitious are less likely to guard information than other more ambitious scientists. And some women scientists organise their laboratories in

[27] Perhaps the strength of students' defence of empiricism is an indication of the way in which scientists who teach students pass on the rhetoric of empiricism which students then mimic.

order to maximise cooperation and minimise competition. In other words, in such cases information is more freely available where women are involved. Levels of scrutiny and availability of information clearly shapes the content of scientific knowledge. Whilst this is by no means purely an issue of gender, gender nevertheless comes into play given the marginalisation and stigmatisation which women in science experience.

9.2.2 Masculinity

I argued in section 3.4 that there is undoubtedly a mutually reinforcing relationship between the male domination of science and the perception of science as masculine. However, I questioned the nature of masculinity and its influence on the practice of science. I criticised psychoanalytic theories, such as object relations theory, for being overly deterministic about the role of psychology in shaping gender, and prone to problematic generalisations. I argued that social factors also contribute to gender identity, and that there were many different 'masculinities'. In this vein, I noted the powerful role of rhetoric about the masculinity of particular scientific methodologies in guaranteeing support and funding for science. I argued that rhetoric could also have a role in concealing and reinventing the actual practice of science, to garner political and financial support. For most scientists, it is now politically unacceptable to define methodologies in science as masculine, yet the association continues in popular perceptions of science. Is there some concrete foundation to the perception that science is masculine?

Section 3.4.1 documented the suggestion by Hubbard and Bleier that the topics and questions of science might be shaped by masculine values, given the male domination of science. Although I recognised the importance of dispelling the myth that science is value-free, I did raise problems with any simple equation between male domination and masculine influence on the topics and questions of science. Similarly, whilst interviewees recognised the shaping of scientific knowledge by scientists' beliefs and values, and emphasised ways in which scientists find what they are looking for, they did not tend to argue that science reflected a 'male world view'. Instead, links were drawn between questions asked in science and gender socialisation of scientists, men's domination of positions of power in government, and funding of research into certain topics in science, as promoted by Western capitalism. The political influence on the topics and questions of science was highlighted: for example policy makers and funding bodies with certain political priorities determine the broad priorities of what science gets funded.

This provides a more complex array of explanations for the topics and questions explored in science than the notion of a 'male world view' shaping research. Rather than privileging one of these explanations over another it seems more appropriate to recognise the way in which each of these factors interact in shaping the priorities of science. Science's links with 'systems of domination' - capitalism, imperialism and patriarchy - and gender ideology of/in science, as discussed in section 3.2, were raised by interviewees. Links were drawn between individual scientists' priorities and those of funding bodies - a major point of commonality between these groups being their sex. Note that scientists in the higher levels of the employment hierarchy interact with policy makers and funding bodies in determining initial research priorities and vetting subsequent research proposals. This takes place either formally, via consultation committees and peer review, or via informal meetings and conversations. Here the notion of male dominated 'invisible colleges' is also appropriate for these coalitions amongst policy makers, politicians and scientists.

Nevertheless respondents noted that the emphasis in science (as documented in sections 3.2, 3.3 and 3.4) is to ignore or deny these various political influences. In addition, the data suggests that many junior scientists must make compromises between their political values and the political values associated with their research (for example militarism). Both scientists' denial of and compromises about the political aspects of their topic of study makes it difficult to see with clarity how scientists' views impact on science. It is only the overt political commitments of a minority of scientists (including feminists) which are seen to guide their research. Not surprisingly, this type of political work is reported to be stifled and marginalised in science.

So, although these is no simplistic male world view manifest in science, the intersection of external and internal political forces determining research questions and topics cannot be divorced from men's position of power, both outwith and within the scientific community. Nor can men's power be isolated as a single causal factor in determining scientific research, as capitalist and imperialist influences cannot be ignored.

Practitioner interviewees provided a variety of descriptions and explanations of the relationship between gender and practice in science. Men's need to separate from nature, which they experience as threatening and alien, was given as a reason for their rhetoric about, and attempts to control, nature. Similarly, men's need to suppress emotion was seen by some as a reason for their attempts to separate emotion from knowledge via so called objective methods, while others linked it with the use of reductionist methods in science. Gender socialisation was given as a reason for men's behaviour in science, especially for competitiveness and reductionism, although it was noted that there is an overlap between the sexes' gendered behaviour. These are all common themes in the feminist critique outlined in section 3.4. Other respondents nevertheless rejected the literal association between science and masculinity, instead favouring a rhetorical association, as introduced in section 3.4. Here respondents viewed 'masculinity' as a label on certain behaviour, eg competitiveness and aggressiveness. It was also suggested that the reason for masculine labels on important features of scientific practice was to exclude women from science

There is further evidence from the student data, detailed in chapter 7, of an association between masculinity and science and of the perception of differences in the practice of science by men and women. The differences between men and women (in areas such as patience when doing laboratory work, and empathy) identified by a minority of students may be evidence of gender socialisation. Nevertheless, whilst some of the topics and approaches in science are perceived as masculine by the majority of practitioners and a minority of students, there is no single explanation for the association: types of social interaction and methodologies in science have been variously associated with men's fear of nature and need to create a sense of control, and with gender socialisation. Students who drew a connection between gender and science also gave a variety of examples and explanations of the influence of masculinity in science. This reflects an ambiguity about the relationship between male domination; essential, social or rhetorical links between masculinity and science; and a 'male world view'. Rather than seeing this as a weakness in respondents' understanding, I prefer to argue that this indicates a complex relationship between masculinity and science. The complexity is increased when these qualities are put into different contexts of the practice of science, which I now consider.

9.2.3 Science in Particular Contexts

What other factors, apart from gender, shape the practice of science, and how are they related? How do such factors and the way they relate vary depending on the subject area, aspect of scientific research - from research aims to analysis - and in different research situations? And how are control, objectivity and reductionism related to their supposedly opposite qualities - respect, subjectivity and holism?

Another explanation for the dominant practices in science, which challenges the emphasis on child development and gender socialisation in the previous section, was also offered by respondents in Chapter 8. Other motives, including prestige, camaraderie and careerism, motivate scientists. Scientists (especially male scientists) were seen by some practitioners to have vested interests in career promotion and securing future funding. It was suggested that, in order to achieve success in science, scientists' work must fulfill the criteria of 'good science'. This was described by some interviewees as meaning results must be tidy and 'publishable', in addition to being seen as untainted by political and social factors. Perhaps scientists therefore utilise the rhetoric of control and objectivity, to garner credibility for their research. In addition to adopting particular explanatory frameworks, scientists might also adopt certain methods with the aim of obtaining 'good results'. I suggest that reductionist research designs and methods are especially suitable because of their tendency to limit the scope of investigation and generate neat, single factor, causal explanations. Practitioners outlined the way in which reductionism is invariably a highly functional research design or methodology. Most importantly, this line of analysis suggests that male scientists have a greater tendency to be focused on success than female scientists. This implies that they are more likely to adopting this rhetoric or approach.

The extent to which these values in science are applied literally or remain rhetorical also depends on the particular context. For example, in certain subject areas reductionist research design and/or reductionist methods are more acceptable, or more easily applied. Astronomy is a good example of a science where reductionist research design tends not to be possible, but where reductionist techniques for analysing data can be applied. Clearly qualities such as control, reductionism and objectivity have different meanings in different contexts. For example 'control of nature' might involve experimental controls, coming up with an explanation and appearing 'in control' in a social group, or it may have a broader meaning like controlling the world's population. Objectivity also has several layers of meaning. For example, some research projects are more objective than others in the sense of being more thorough and accurate, in their use of proper statistical controls. Moreover, especially in the case of reductionism, there is no clear boundary between the supposedly opposite sides of the dichotomy which feminists argue informs the philosophy of science - the dichotomy between masculinity and femininity and its association with reductionism and holism, control and respect of nature and objectivity and subjectivity. Rhetoric and practice in science can involve both sides of this dichotomy; for example, rhetoric about controlling nature need not be distinct from rhetoric about respect of nature. Equally, reductionist methods may be a part of a holistic research design. The data from the student interviews - when they argue that qualities such as intution and rationality should both be included in 'good science' -

further confirms the combination of qualities related to the supposedly opposite sides of the masculine-feminine dichotomy in science.

In sum, particular contexts clearly alter the application and configuration of particular research techniques.This evidence further emphasises the point made in the previous section - it is over-simplistic to argument that science is masculine because objectivity, reductionism and control of nature are masculine - as it highlights the different meanings and manifestations of these concepts in science. There are several meanings behind each of these concepts, not all of which fit in with the feminist critics' emphasis on emotional suppression. Scientists who adopt a particular rhetoric or approach are also motivated by the desire for successful scientific careers. Moreover, the dichotomy between these supposedly masculine traits and their opposite feminine traits, is not always manifest in practice, as the combination of reductionist and holistic methodologies in science shows. In the next section I attempt to integrate the points made here with those in the two previous sections, in order to develop a preliminary theory of the relationship between gender and the practice of science.

9.2.4 Science as a Male Domain

Is it possible to tie together the male domination of science, different explanations of masculinity in science, and properly contextualise this in an understanding of scientific practice? I suggest that characterising science as a male domain might prove a useful starting point in understanding the complexity of this relationship.

'Male domain' highlights the male domination of science in terms of numbers and sphere of control and influence. The emphasis on the word 'male' as opposed to 'masculine' is not meant to imply that masculinity is an essentially male quality, a position which I have criticised throughout this study. Rather it is intended to highlight the importance of the material reality of male domination in science, and to use this as a starting point for understanding associations between 'masculinity' and science. Perhaps by starting from a full appreciation of the male domination of science the relationship between gender and science will become more clear.

Science is a male sphere of influence and control. It is women who must adapt to the typical lifestyle of the scientists and the prevailing style of communication. Men, on the other hand, are much more likely to fit in with the 'protocol' of science. There are male gatekeepers who perpetuate male domination. Women seem to be experienced as a threat and can therefore find themselves marginalised or stigmatised, particularly if they are feminists. The reverse is also true, some women scientists are on the margins of science because they have no interest in a conventional scientific career. It may be that the unconventional nature of these women's work and criticism of science is experienced as threatening by conventional scientists. The 'Catch 22' situation - where women are penalised for conventional behaviour which is seen by male scientists as unsuitable for their sex as well as being penalised for unconventional behaviour which may be viewed as suitable for their sex, but is unsuitable in terms of scientific protocol - is further illustration of their apparent threat to the male domain of science.

I suggest that this notion of science as a male domain can be used to better understand the mechanisms by which science is perceived as masculine. Although appeals to male psychology in the feminist critique of science cannot be explored directly, the data obtained in Chapters 7 and 8 does challenge the primacy of their role in explaining 'masculinity and science', as it introduces other explanations of motives for certain behaviour in science, which are nevertheless associated with stereotypes of masculinity.

Values integral to success in science - confidence and ease with the combative style of communication and competitiveness, and the appearance of lack of emotion - are thought of as masculine in popular culture. Although partly based on a gender socialisation and child development, the association between gender and particular types of behaviour is not necessarily entirely literal, and may also be rhetorical.

Historically, the rhetorical links between science and masculinity acted to exclude women from science, and to garner political and economic support for science. Now, scientists no longer use the rhetoric of gender associations, but favour a rhetoric of neutrality; it is feminists who now make links between gender and science. Perhaps thinking of masculinity as a label placed *by feminists* and other women in science on certain activities will help in understanding the relationship between gender and science.[28] This is a way of putting Keller's argument that 'gender is the label a culture places on sex' (Keller, 1992a, p46; documented in section 3.3) into the particular context of science. I am arguing that there is not just one label or culture but many labels which different groups in particular cultures place on the sexes' practices.

This analysis is not mean as a slur on feminist theory. There are good reasons why feminists and other women concerned about science adopt this approach. The notion of the masculinity of science draws attention to the sexist double standards in the 'Catch 22' situation described above. The extension of the analysis to consider the masculinity of the methods of science also challenges the virtual neglect of this aspect by mainstream sociology of science and the notion that scientific methods are value free. Moreover, to associate this behaviour with male child development or gender socialisation, and to see it as embedded in the actual methods of science, provides a neat explanation for the persuasiveness of the association between *maleness* and success in science.

---

[28] Richards and Schuster (1989) make a similar argument when they discuss the way in which feminist discourses about scientific methodology, and serve as 'flexible rhetorical resources in the social process of knowledge construction and negotiation of knowledge claims', (p697), although they argue that such narrow methodological discourses are unhelpful for feminist intervention in science. As I explain more fully in the main text that follows, I take the view that when used explicitly, and within a wider theory of the organisation of science, such discourses can be positive.

Nevertheless, in my view this type of 'catch all' analysis has more disadvantages than advantages. Most significantly it alienates many women scientists, making them hostile to feminists' attempts to understand the gendering of science. It also masks important dimensions of the practice of science - the 'rich diversity of meanings and practices' that Keller refers to (Keller, 1992a, p48; see section 3.43) - on two counts. First, it underemphasises the historical role of scientists' rhetoric about science and gender. Second, it hides other reasons and motives behind scientists' use of particular methods and rhetoric of neutrality.

Instead I propose that the *labelling of science as masculine by feminists* should be made explicit, and qualified in the following way, in the particular context of the male domain of science. Particular behaviour in science has been labelled masculine by feminists and women in science because it is mostly displayed by men. In contrast, when women in science display the same behaviour, for example competitiveness, they can be stigmatised or marginalised.

It is also important to recognise that there are different versions of masculinity associated with science. I have given examples of macho bravado amongst male scientists involved with animal experimentation and at conferences in my empirical material. Perhaps this is a case of the reinforcement of masculinity in the work place (drawing from Cockburn, 1985). Note that versions of masculine bravado are not necessarily uniform across all scientific disciplines. It may be the case that different sub-communities in science have different forms of masculine behaviour. There are other stereotypes of masculinity in science, eg 'computer nerds'. Traweek has documented the different cultures of theorists and experimentalists working in high energy physics, including their dress code (Traweek, 1988). In each case, the shared masculine culture has the effect of promoting male camaraderie which women can experience as alienating. There is also the possibility of similarities between different masculine cultures in science which contribute to a general sense of camaraderie which male scientists from different disciplines share.

Objectivity, control of nature and reductionism cannot be considered to be masculine in any simplistic sense. These qualities, in various forms and configurations with other supposedly 'feminine' traits, for example intuition, remain important in science today precisely because of their rhetorical force or practicality for scientists' wishing to advance their careers in science. Although women scientists can adopt the values of objectivity, reductionism and control of nature, those such as feminists, on the margins, who adopt unconventional approaches to science are likely to reject them. This enhances feminists' association of objectivity, reductionism and control of nature with masculinity.

The concept of the male domain of science can also explain why other women scientists and students reject the masculine label on science, especially when it is applied to methodologies. Perhaps these women's denial of and even outright hostility to the notion of science as masculine is because of their interest in a successful career in science, which depends upon either being part of or, at the very least being tolerated by, the male domain of science, an important feature of which is the appeal to science as value free knowledge.

In sum, the male domain of science incorporates the concept of male domination of the numbers of scientists and concept of males' sphere of influence in science. It provides an explanation for the perpetuation of male domination in science: male scientists' 'cloning' of male junior scientists; and their repeated use of certain methods and adoption of certain behaviour necessary for success. There is no simple or single association between masculinity and science. I continue to accept that there is a way in which the perception of science as masculine is reinforced by male scientists' adoption of these approaches and vice versa. However, while object relations theory and gender socialisation may partly explain male scientists' behaviour, I have chosen to develop the other side of this relationship - the way in which perceptions of masculinity are related to the powerful position of men in science - which I have argued is neglected in the feminist critique of science. I focus on the rhetorical links between masculinity and science, the social oganisation of science and the requirements for success within it. Although the association with masculinity is now denied by most scientists, the criteria for success in science remain broadly similar. It is useful to think of 'masculine' as a label feminists and other women scientists place on behaviour and methods in science because they are developed and perpetuated by men for the purposes of prestige, camaraderie and mutual support. Women must adopt this behaviour to succeed, but can also be penalised for so doing. This can be related to the use of unorthodox methods (eg a greater emphasis on holism) by marginalised women in science, especially feminists. There are undoubtedly several different types of 'masculinity' in science depending on the particular context. Other women, aiming to be successful on the same terms as men tend to deny the association with masculinity and science, particularly between scientific methods and gender. I suggest that this is necessary for them to avoid hostility from the male domain.

The concept of the male domain of science is only a starting point for understanding gender in the practice of science. Three major questions remain. First, the way in which early child development, gender socialisation, and the construction, or rejection, of gender labels within science interact, requires further investigation, ie the mutually reinforcing relationship between masculinity and science, which functions within and outwith science, in the wider society. Science is clearly a powerful institution in the wider society, which has male domination in common with other powerful institutions. Second, the questions raised in Chapter 3 about scientists' use of language as a rhetorical device have not been adequately dealt with here. Nevertheless the emphasis on rhetoric and labelling in this preliminary analysis might provide a way of developing a future analysis of practice and language. Third, the complexity of the scientific enterprise has only been touched upon here. Answers to the important questions raised in Chapter 3 concerning the difference between pure and applied research and between scientific workers and the elite scientists have yet to be incorporated into the picture of science and gender. Nevertheless, the complexity of the interaction between sex, gender and science has been established, and any explanation based on single causal factors rejected. The importance of particular context and rhetoric has also been established.

9.3 Feminism and Science

9.3.1 Feminist Scientists

The main questions explored in this section are, in the 'best version' of a feminist science, who could be a feminist scientist and what do feminist scientists need to have in common for such a feminist science? The answers are drawn from a consideration of the data detailed in Chapter 8, that is the views and experiences of feminists and women sympathetic to feminism who are either critics or practitioners of science. I contend that these women, while not necessarily labelling themselves 'feminist scientists', do give pointers to what the best criteria for feminist scientists might be.

As noted in section 9.2, a significant number of these women felt marginalised in science, either through choice and a desire to adopt an unconventional approach, or as a penalty for their lack of conformity. Many of the women who were or had been in such a position were in the life sciences. Women with experience in the physical sciences appear less able to adopt radically different approaches, and were more likely to show their feminism in more conventional ways, encouraging and supporting women in science. Different women in, or close to, science hold different views on the extent and nature of the 'masculine' influence on science. Their feminist politics are also different - some placing greater emphasis on getting more women into science, and others being more concerned to transform the methodologies of science. In addition, their positions in the employment hierarchy and disciplines of science varies. However, these women have in common their exclusion, albeit to varying degrees, from the male domain of science.

Two features of respondents' views require further consideration. First, their calls for more women in science and for a greater diversity of scientists shows that they view diversity in science as a strength. Second, the concern with explaining the relationship between gender and science in feminist theory was viewed as irrelevant by some respondents. Others took the view that it was important. What does this call for more diversity, and the amount of actual diversity in views in relation to gender and science, mean for feminist epistemologies of science?

I highlighted the tension between the views of the individuals and the community view in my initial analysis of feminist epistemologies of science when I rejected feminist standpoint theory as a flawed basis for theorising about a feminist science (see sections 4.3 and 4.4). An important aspect of my critique was the importance of avoiding an overly-determinist essentialist position, which would alienate women and men in science and lead to a relatively powerless feminist science on the fringes of mainstream science. I contrasted Haraway's views on coalitions of interest amongst feminists, ie shared politics which would form the basis for their evaluation of their knowledge claims, with Harding's emphasis on a more permanent commonality, formed on the basis of a set of well defined priorities and shared views, ie a more consistent basis for judging knowledge claims, and asked if the two were incompatible (see section 4.4.4). To what extent is commonality in views likely and desirable in a feminist science? A similar question arose concerning feminist empiricism: the evaluation of knowledge cannot be purely based on community reflexivity, and must surely require some individual reflexivity - how are the two related?

From Chapter 8 the point of commonality which the respondents share is their exclusion from the male domain of science and their commitment to equality in science, in terms of numbers of women and access to power and influence. This underpins their views about an 'ideal science'. There is a diversity of views on how to achieve this, and the extent to which the traditional methods of science should be altered, but this diversity is not viewed as problematic by the women I interviewed.

There was a strong emphasis on collaboration, diversity, egalitarianism, democracy and creativity in their responses to questions about an ideal science - all of which are qualities which nurture diversity within the bounds of a shared common goal of a better science.

In my view this balance between commonality and diversity in interviewees' views provides useful pointers for thinking about the criteria in the 'best version' of a feminist science for feminist scientists. Diversity of opinion is not necessarily a hindrance to a workable feminist science, when opinions are shared in a community of scholars who value creativity and democracy. The extent of commonality in respondents' views allays my earlier concerns about Haraway's 'coalition politics' (Haraway, 1986). On reflection this position appears to be a workable solution to the problem of a feminist science based on a feminist standpoint. In contrast, my earlier criticisms of Rose's, Hartsock's and Harding's feminist standpoint are mainly reinforced by my empirical findings. A feminist standpoint is simply not relevant for the majority of feminist practitioners of science, whose versions of 'ideal science' make little reference to a feminist standpoint as a guiding principle in their 'ideal science'. Furthermore, a significant number of responses on questions about epistemology criticise feminist epistemology of science in general for being unrelated to the practice of science, especially for being over analytical about orthodox science being based on a masculine or male standpoint - a component of feminist standpoint theory . Others argued that feminist epistemology was too concerned with defining a feminist way of doing science based on women's way of knowing, which is important in feminist standpoint theory. More importantly though, diversity of experience and perspectives highlighted and valued by respondents, is not allowed for in feminist standpoint theory. In my view, the mixture of views which might evolve from an emphasis on diversity would constitute an important strength of a future feminist science - generating both creativity and an openness to different perspectives. Diversity would be compromised by an emphasis on scientists adopting a feminist standpoint, and the potential for the growth of feminist science would therefore be hindered. Nevertheless, the notion of many feminist standpoints, rooted in different experiences, is still valid. Moreover, Collins' notion of the feminist scholar's perspective being based on their 'outsider within' status has empirical weight when considered in the context of women's marginal position in the male domain of science. These are two positive ways of using the notion of a feminist standpoint in science which I did not anticipate in my earlier critique.

I suggest that the best criteria for feminist scientists is *inclusion in a feminist science community of people from a variety of backgrounds who hold a range of views, but who are united by a common goal of equality for women in science* (and, as I shall show later, a corresponding goal of equality for women in all of society). Given my rejection of a feminist standpoint and its essentialist overtones, there is no reason to suggest that feminist scientists would only be women. Men who held these views could also be feminist scientists. I can envisage various feminist 'interest groups' working in coalition with scientists with similar concerns (eg around environmentalism or anti-militarism). There would be, as there are now, groups of more 'liberal' feminists who emphasised equality of access and others who were more concerned with changing the methods of science. Crucially though, as I shall go on to show, a commitment to equality in science depends upon rejecting the notion of 'value free' scientific knowledge which is an important feature of the current male power structure in science.

9.3.2 Topics and Questions

Choice of topics and questions in conventional science were viewed by interviewees as limited by the constraints of funding and scientists' careerism. For example, investigation in certain fields was seen as shaped by scientists motivation to 'blaze a trail' with new research, or to work in 'trendy' areas where funding is readily available. The lack of research into questions of interest and importance to ordinary people, especially ordinary women, was criticised by interviewees. Emphasis was placed on research which would act to empower the community.

A variety of alternatives to this current situation were put forward by feminist practitioners. A greater diversity of topics was called for, as was more consideration of the ethics of research, especially in relation to animal experimentation. There was not, however, one set approach. As one woman's account of the history of her various different research areas suggests, questions of interest to feminists can even involve conflicting ethical positions, in this case with regards to animal experimentation.

Questions which orthodox science has failed to address were proposed by practitioners as important areas of study. These might involve consultation in the community to identify important concerns of less powerful groups. In addition, questions which addressed the complex problems often ignored in today's science, with its emphasis on reductionist research design, could be addressed. This might involve interdisciplinary research, eg collaborations between physics and biology on studying the effects of radiation on organic materials.

One problem with these proposals is the predominance of health-related questions. Although this would not necessarily only involve the biological sciences - interdisciplinary research with the physical sciences could be fruitful - the lack of suggestions for research topics in the physical sciences raises an important difficulty with the notion of feminist questions in science. Are feminist questions in science solely related to women's life in society (health being an important aspect of life dealt with by scientists)? In what way is extending the topics and questions of science to take account of issues important to the community 'feminist'? Can feminists 'lay claim' to these topics of investigation?

Perhaps a starting point for answering these questions is a consideration of how the basic aims of feminism - equality for women - can be extended to a philosophy of equality in society generally. This would involve challenging the power structures which perpetuate inequality by driving scientific research in directions which do not empower, and can even do harm to, ordinary people - eg imperialism and capitalism. However, in my view it would be wrong to argue that this was an exclusively feminist aim and therefore that these are exclusively feminist questions. The radical science movement in particular placed an end to inequality as a central element of their aims and practice, although a commitment to sexual equality is not given such a strong priority as it is by feminists. Instead I argue that it is more useful to think of the 'best version' *of a feminist science as exploring questions of interest to feminists, in all their diversity, given their common commitment to sexual equality and their various links with other political interest groups in and outwith science.*

I now move on to consider the case of feminist methodology of science, bearing in mind these questions about whether such a term is appropriate in the 'best version' of a feminist science.

9.3.3 Methodology

Choice of methodologies in science were also criticised by interviewees in Chapter 8 as too limited - in particular the overemphasis on reductionist approaches. Crucially, the claim that science is objective was rejected by the majority of feminist practitioners, and the rhetorical force of this claim in orthodox science was acknowledged. Scientific knowledge was viewed as socially shaped by the priorities of funding bodies and policy makers in addition to scientists' own subjectivities: emphasis was placed on scientists 'finding what they are looking for'. The importance of scientists' passion for their work in shaping the questions they asked and the answers they found was highlighted. Different 'layers' of meaning of objectivity were exposed, not all of which were rejected by practitioners, for example statistical approaches to reducing 'bias' were described as important by one interviewee. The role of control of nature and reductionism was also shown to vary depending on the particular context, as discussed in section 9.2.3 - for example reductionism can apply to research design or methods.

More holistic methodologies were favoured by feminist practitioners, although not at the expense of reductionist methods where these were more appropriate. Clearly methodologies cannot be divorced from the questions asked by feminists - what is important is to find the right methodologies for the task of answering these questions. A commitment to objectivity in terms of the ultimate aim of an accurate reflection of nature was evident in practitioners' 'ideal science'. Rules for scientific investigation and critical discussion were viewed as part of this process. Significantly, other aspects of 'traditional' objectivity were rejected - particularly scientists' attempts to distance themselves from the object of study. A thorough investigation of subjectivities which shape knowledge was viewed as part of the process of being objective, in the sense of being more accurate. More awareness of biases which might affect science, and scientists' acknowledgment of where their background ideas and assumptions and the social context of their work affected their results, was advocated.

How does this position square with the feminist critics' earlier treatments of a feminist science and the later feminist epistemologies of science? Does it help in answering other questions raised in my critique of these epistemologies concerning the criteria for evaluating knowledge claims? Should evaluation of knowledge claims be based on appeals to 'closeness to nature' or 'better politics'? What would be the process of critical evaluation of knowledge claims? Should feminists promote a feminist science via exposing the 'myth of objectivity' or should they utilise it where appropriate for the extension of their own ideology of equality? And what is the possibility of the 'reverberation' of change through different scientific disciplines?

There is no simple answer to any of these questions, neither is it possible to answer them completely with the data provided. The answer is instead a general one, which takes as its basis *the tension between objectivism and relativism* evident in practitioners' responses to questions on methodology. In my view this resonates with the treatment of objectivity in the feminist critics' initial formulations of a feminist science, detailed in Chapter 4, and the later feminist epistemologies of science (detailed in Chapter 4). In particular, Fee's treatment of objectivity is a highly appropriate way of understanding the case made by interviewees (see section 4.2). To recap, Fee argues that objectivity is 'sufficiently vague to carry with it a multitude of meanings' (Fee, 1982, p17). Fee rejects what she calls the 'hierarchy of distances' in objectivity, which is manifest in four ways: the treatment of the production of knowledge as separate from its social use; the separation between scientific rationality and emotion in the language of science, which she argues is a 'pervasive and powerful aspect of the mythology of science' as scientists are often deeply committed to their work (Fee, 1982, p18); the distance between the subject of study and the object of study, which legitimates the domination of nature; and the view of science as separate and distinct from society. Fee's main point is that all of these aspects of objectivity are false, and that science is political and emotional, and not separate from nature.

Fee also highlights positive meanings of objectivity which mirrors respondents' rejection of relativism, favouring the:

> constant process of practical interaction with nature; willingness to consider all assumptions and methods as open to question ... idea of individual creativity subjected to the constraints of community validation through a series of recognised procedures (Fee, 1982, p16).

In addition, the importance of understanding and respecting the independence of nature was stressed by interviewees, in a similar way to Rose's and Haraway's arguments for a type of 'constrained realism' in science.

My initial treatment of this tension between objectivism and relativism, developed in my review in Chapters 3 and 4, is challenged by practitioner's responses to questions on methodology. I now argue that my earlier focus on *resolving* the tension between objectivism and relativism was flawed. Instead I favour a recognition of the *necessity* of such a tension in scientific practice.[29] This tension functions on three main levels.

---

[29] A similar position is taken by some scholars in technology studies. For example, Williams and Edge describe a position of 'modified realism'(Williams & Edge, forthcoming).

At the epistemological level feminist practitioners of science are both committed to the most accurate representation of nature and to locating this representation in the particular context of their beliefs, values and assumptions. In their view the tension between objectivism and relativism remains a fundamental feature of the practice of science, whether it is made explicit - which they favour - or not. This tension is fundamental precisely because neither a 'true' representation of nature or a thorough uncovering of the subjectivities of research is ever entirely possible. On the one hand, nature is always viewed through social lenses. There are a range of different lenses through which we view science, based on our values and beliefs about the social and natural world. It is not only difficult to represent nature accurately because of our political standpoint, but also because of the complexity of the natural world, which we can only represent in crude models. These models can never be proved, only disproved. On the other hand, our beliefs and values are equally complex and the social processes of knowing can never be entirely transparent. Philosophers and social scientists share with scientists the inability to ever prove their theories of knowledge.

In a second way the tension exists for scientists when justifying their research. This is especially true in the case of feminists operating in the hostile male domain of science. Feminists might appeal to realism and objective methods in certain circumstances, eg when criticising sexist science for 'bad' methodology, but in different circumstances might emphasise the importance of the political implications embedded in certain research, either as a strategy for promoting or dismissing certain results. In other words, on the one hand feminists appeal to better empirical representation of nature, and on the other to better politics in certain scientific knowledge.

Third, the tension between objectivism and relativism spans the different subject areas and research questions in science. As I have already argued, objectivity is related to the particular context of scientific research. For example, a commitment to thorough statistical analysis of data is typically used in orthodox science to reduce the potential for 'bias' in results. Whilst this by no means guarantees objective scientific knowledge, I would argue that it does function in reducing certain types of error, and therefore contributes to a more 'accurate' representation of nature. These methods are clearly more appropriate in answering certain research questions than others. Similarly the chance of a clearer understanding of the political content and implications of science may vary depending on the research area. For example, in the area of research where comparisons are made between the sexes, the political implications may be more obvious than in 'less contentious' research where political and social subjectivities are less transparent. The existence of these levels of objectivity and relativism in the context of variations in scientific investigations points to a complex picture of the relationship between different disciplines. It implies that without a clearer understanding of similarities and differences in scientific disciplines, in terms of subject matter, research questions and levels of objectivity and relativism, it is not possible to 'map' the process of change towards a feminist science throughout these disciplines.

This characterisation of the tension between relativism and objectivism in a feminist science has parallels in practitioners' preferred role for reductionism and holism, and control of and respect for nature in science, as documented in Chapter 8. Perhaps then it would be helpful to also think of reductionism and holism, and control of and respect for nature, as in another productive tension in this 'best version' of a feminist science. The tension can also be thought of as existing on three levels - in terms of epistemology and how this is put into practice; in feminist scientists' justificatory strategies; and as depending on the particular context of science. Epistemologically, feminist scientists could locate reductionist understandings of nature in the wider context, that is in a more holistic understanding. Control of nature and respect for nature are also inter-related. As in the case of objectivism and relativism, in both these cases, no component is ever either entirely possible (or entirely desirable). Second, feminists might appeal to reductionism or holism, and control of or respect for nature, depending on the aims of their research or their audience. And third, the choice of particular methods or approaches is always located in the particular context of the subject matter and research questions of science.

Does this treatment of the tension between objectivism and relativism, reductionism and holism, and respect for or control of nature, in this 'best version' of a feminist science constitute a feminist methodology or feminist methodologies? As in the case of questions that might be tackled in a feminist science. I do not consider it appropriate to call approaches and techniques which feminists might employ 'feminist methodologies'. In particular, the recognition and exploration of the tension between objectivism and relativism is not exclusive to feminists, or the natural sciences. Indeed, many researchers in the social sciences now consider a recognition of this tension as fundamental to good research design (eg Jensen & Janowski, 1991). This means that the term feminist methodologies is more problematic than helpful in defining the 'best version' of a feminist science. Rather it is more useful to describe the 'best version' of a feminist science as *involving a set of methodologies which recognise and explore the tension between objectivism and relativism/reductionism and holism/control of and respect for nature in the three ways outlined above: in terms of epistemological commitments; justificatory strategies; and in the particular context of different subject areas and research questions.*

9.3.4 Organisation

The formal organisation of science, such as the employment hierarchy, and the more informal organisation, such as communication networks, are dominated by men, and are an important feature of the male domain of science. Feminist practitioners wanted an end to these exclusionary practices. They advocated more flexible working arrangements, and a more collaborative and supportive environment. Egalitarian organisation was favoured instead of hierarchy. Some also called for science departments to be organised differently, involving a critical evaluation of science alongside the practice of science in a similar way to English Literature departments. In addition, feminist practitioners advocated more support for female science students and training science students to be more reflexive and aware of social and political issues in science.

In Chapter 4 I criticised feminist epistemologies for an inadequate consideration of the organisation of science but singled out Longino's and Nelson's feminist empiricism as being concerned with organisation. Feminist practitioners share their concern and an awareness of the necessity of organisational changes if other changes are to be realised. They also criticised the gulf between philosophy and science, especially the difficulty in translating epistemology into practice, as do Longino and Nelson when they speak of treating science as practice not product. The lack of consideration of organisational change in the bulk of feminist epistemology is, in my view, the single most significant contributing factor to this gap between theory and practice.

I would go so far as to argue that *re-organisation of science is fundamental to the development of the 'best version' of a feminist science. Key to a workable definition of a feminist science is the ending of the male domain of science ie an end to male domination in terms of numbers and power.* This, in turn, requires an end to the formal and informal organisation of science which is a central element of such domination. The way in which this re-organisation is related to criteria for feminist scientists, and questions asked and methodologies adopted by feminist scientists is explored further in section 9.4.

9.3.5 Science and Society

Longino and Nelson highlight the importance of change both within and outwith science in the promotion of a feminist science. This is underlined by the empirical material. The interaction of the role of funding agencies and governments with the male domain of scientists determines the type of research that gets done. The methodologies adopted are also indirectly shaped by this relationship. For example, scientists' aiming to develop a career in science will partly base their choice of methodologies on what they view as acceptable to the coalition of interest between the male domain of science and the funding bodies and policy makers, ie methodologies which will provide 'good' and publishable results. The rhetoric of objectivity is another important feature of the male domain of science. As I have previously argued, appeals to objectivity are part of the protocol in the male domain of science - as objectivity is highly valued scientists seeking kudos within the male domain of science will utilise this rhetoric. This also applies to scientists in their interactions with the wider community - clearly appeals to objectivity garner political and financial support as well as authority amongst the lay public.

Feminist practitioners advocated a more democratic science, in which scientists fulfill their responsibility to the wider community. They argued that scientists should be more responsible for communicating the reasons behind their research to allow people to make decisions about what type of research gets done, and to properly evaluate the results. Part of this process is a breaking down of the myth of objectivity, and thus the authority of scientists: feminist practitioners saw scientists making their exploration of the subjectivities which affect their work transparent in the wider community as well as the scientific community as an important part of this responsibility. Smaller, longer-term grants, which allowed for more creative science, were also favoured. Clearly, for this to happen, changes in the public domain, governments and funding agencies alongside changes in the scientific domain are necessary. This challenges the notion of a feminist science disembodied from society, highlighting the importance of feminist values in science depending on feminist values in the wider society, as stressed in Chapter 4.

Feminist scientists' concern to promote equality in science takes as its necessary corollary a concern to promote equality outwith science. This is highlighted in the discussion of topics and questions in this 'best version' of a feminist science - where empowerment of women in the community in addition to a general commitment to equality was an important theme. Similarly, a commitment to equality in the wider community would be necessary to sustain increased numbers of women in science; and challenging the male domain of science, a central feature of the feminist re-organisation of science, would require a corresponding challenge to the male domain of funding and policy making bodies. As illustrated in section 9.2, 'coalitions of interest' between scientists and funders are marked by their male domination. In the same way that male domination in and outwith science is mutually reinforcing, promoting a feminist science from within the existing scientific institutions and promoting equality in the wider society, are mutually reinforcing. In other words, to reformulate Fee's and Longino's arguments which suggest that a feminist science is impossible without a feminist society, and start from the premise that a feminist science is *dynamic* rather than static, *the process of feminising science and feminising society are interdependent.*

9.3.6 Feminist Science

To recap on this section the criteria for the various components of this 'best version' of a feminist science are as follows:

1. The inclusion of people from a variety of backgrounds in a feminist science community who hold a range of views but who are united by a common goal of equality for women in and via science.
2. The exploration of questions of interest to feminist scientists, in all their diversity, with their common commitment to sexual equality and their various links to other political interest groups in and outwith science.
3. The use of methodologies which recognise and explore the tensions between relativism and objectivism, reductionism and holism, control of and respect for nature. This is manifest in feminist scientists': epistemological considerations; justificatory strategies; and guides their approach in the different contexts of scientific practice.
4. A re-organisation of science in ways which challenges the male domain of science.
5. A corresponding challenge to inequality in the wider society, in particular the intersection of the male domain of scientists, policy makers and funding bodies and

a recognition of scientists' responsibility to communicate the subjectivity of science to the wider community.

I suggest that Longino's notion that a feminist science is the science that feminists do (Longino, 1988) is a useful way of thinking about this best version of a feminist science that I propose. This deceptively simple concept is appropriate on three counts. First, it involves a recognition of different 'feminisms' and particular contexts of science. Second, following on from this, it places no prescriptions on the topics or methodologies involved in a feminist science. Moreover, these are seen to be intimately linked with each feminist scientist's brand of feminism, and their own subjectivities, and grounded in the particular context of the science which they practice, eg the particular subject matter and research questions. Third, it avoids the problem of 'appropriating' topics, questions, and methodologies already important to other groups and traditions in science, and calling them feminist.

Unfortunately some of the more detailed questions raised in Chapter 4 cannot be answered in this best version of a feminist science, for example, the potential for the reverberation of feminist change throughout scientific disciplines has not been established. This is due, in part, to the reliance placed on feminist practitioners' imagination, and the 'broad strokes' which go to make this picture of a feminist science. Nevertheless, this is a useful starting point in discussing a practical framework for a feminist science. This linking of feminist epistemologies of science with an understanding of the practice of science makes three main contributions to the project of feminising science. First, it highlights the importance of organisational change, as discussed by Nelson and Longino. Second, it makes explicit the necessary tension between objectivism and relativism which is implicit in all of the feminist epistemologies and introduces two other similar tensions - between reductionism and holism and between control of and respect for nature. Third, it favours diversity over restricted definitions of practice and recognises the powerful role which this diversity could have in strengthening moves towards a feminist science. This does not mean that a feminist science is without established procedures and likely to be dysfunctional. This commonality is based on the four points outlined above.

In the next section I consider the processes involved in moving towards this ideal vision of a feminist science. This is an important part of this study which starts from the premise that a feminist science must be practical and achievable from within the existing institutions of science. Many of the questions raised in Chapter 4 concerned, not the content of a feminist science, but the processes necessary to achieve such a science. I hope to provide answers to these questions by drawing on the empirical data and, thereby, to suggest practical strategies for change.

9.4 Feminising Science

9.4.1 Integrated Strategies

There are five main *processes* involved in promoting this 'best version' of a feminist science. The first is *encouraging* people who are from a variety of backgrounds, and who hold a range of views but are united by a common goal of equality for women in and via science, into the feminist science community. The second is *exploring* questions of interest to feminist scientists, in all their diversity and with their various links to other political interest groups in and outwith science. The third is *developing* methodologies which recognise and explore the tensions between relativism and objectivism, reductionism and holism and control of and respect for nature, in epistemological considerations, justificatory strategies, and in particular contexts of scientific practice. The fourth is *reorganising* science to challenges the male domain of science. And the fifth is *challenging* inequality in the wider society, especially at the intersection of the male domain of scientists, policy makers and funding bodies. When thinking about how to achieve such changes, it becomes clear that the *processes of change are interdependent.* In my view, organisational change is the 'lynch pin' of this process. Without organisational change other changes - in practitioners, topics, methodologies and links with the wider community - cannot follow. The organisation of the male domain of science currently operates, informally and formally, to limit change in each of these categories. I now consider the process of encouraging more feminist scientists and sustaining feminist practice of science, to illustrate this point. I then discuss how promoting methodologies favoured in the 'best version' of a feminist science which I suggest is linked to other changes. Finally, I consider the relationship between the different disciplines of science and how this shapes the process of feminising science.

Feminist science requires feminist scientists. This, in turn, requires more women in science, and means promoting feminism amongst both female and male scientists. The present processes of getting more women into science are described in the women in science literature, reviewed in Chapter 2. Increasing the numbers of women in science requires developing girls' interest in science, encouraging women to study science at university, and providing a good working environment for women once they are in science. This latter issue requires challenging the working patterns in science, and the exclusionary practices of the male domain of science. Feminists already in science have joined together to start this process (Zorra and Baltimore Women in Astronomy are two examples). On a more local level, change in the work environment of the laboratory can be instigated by senior feminist scientists by encouraging more collaborative practices.

Nevertheless an important criticism of the women in science literature is its implicit acceptance of the notion of value free knowledge. Whilst I am advocating a diversity of feminists with a range of interpretations of feminism and science, an acceptance of the subjectivity of science is central to dismantling the male domain of science and promoting a more egalitarian and democratic feminist science. The male domain of science relies on the rhetoric of objectivity to sustain its authoritative position in the community, and the rhetoric of objectivity has an important function inside the male domain of science - as a resource to garner support from senior peers and to dismiss science, such as science practiced by feminists, as biased and therefore weak. Therefore, for the topics and questions in science to be made more relevant and accessible to ordinary men and women, for a more open and creative approach to knowledge to be encouraged, and ultimately for an end to the male domain of science, the myth of value free science must be exposed and rejected by feminist scientists. Organisational changes such as changes in funding agency boards (to include members of the public) and more small scale grants for longer periods of time are also required to facilitate the development of a feminist science community. These changes involve dismantling the male domain of science and thus discrediting their appeals to scientists' expert role in creating 'objective facts'.

It is important to overcome the present hostility amongst some scientists, especially women scientists, to a feminist science. I suggest that characterising science as a male domain might be a fruitful approach. This avoids problematic associations with essentialism and the focus on male psychological needs, which are greeted with hostility from many scientists (male and female). I suggest that the emphasis on the constraints placed by the organisation of science on scientists' practices, as opposed to explaining masculinity and science, will have more resonance with scientists' own experiences, and will therefore be more relevant and, hopefully, more acceptable. Instead of perpetuating the rhetoric of masculinity and science, an emphasis on the rhetorical quality of claims to neutrality might be more meaningful and less alienating to working scientists. Moreover, in my view, the corresponding emphasis on feminising science - ie ending the male domain of science, in favour of a more egalitarian, democratic and socially useful science which, crucially, does not abandon the search for better knowledge, the use of reductionist methods, or the aim of control (eg where this is not at odds with caring for nature) - will also be more agreeable than the more utopian claims of feminist epistemologies.

The promotion of feminist science also requires organisational change. A forum for discussion amongst scientists is necessary for the message to be heard. This relates to changes in teaching practice, which is discussed further in section 9.4.3, and a challenge to the authority scientists gain from being viewed as 'fact makers'. If a feminist science is to be successful, scientists need to become more reflexive about their work, and aware of the critiques of science coming from the social sciences and feminist movement. This awareness depends upon cross-disciplinary seminars, and meetings, in addition to a change in scientists' public role, as I shall show in the following section. Feminists in the social sciences and philosophy could play a more involved role in feminising science if they took part in this type of interdisciplinary forum. Their work would also benefit from more understanding of scientists' practice - as this thesis hopefully shows. I take the view that social theories about science benefit from grounding in practice - this makes them more accurate, more accessible to scientists, and more useful in precipitating change (if that is part of their agenda). Although feminist epistemologies of science at present play a role of 'mirror for reflection' for a minority of feminist scientists, their saliency would presumably be increased if they were more accessible and relevant to a larger audience.

The move towards the suggested 'best version' of a feminist science, would involve recognising and exploring the methodological tensions outlined in point 3 of section 9.3.6. At present a minority of feminist scientists are developing methodologies in this way in the life sciences. Others have ideas for feminist research in the physical sciences. How might feminists further develop methodologies along these lines?

In approaching an answer to this question, it is useful to consider why feminist research in the life sciences is more developed. This is related to the numbers of women in the life sciences, and the corresponding number of feminists in addition to the immediate relevance to women's biology. The feminist critique of the biological sciences, especially human biology, and research into sex difference, undoubtedly proved to be a resource, or focus, for alternative feminist methodologies to develop. The small numbers of feminists and the lack of feminist suggestions for research topics in the physical sciences, in addition to the tendency for the feminist critique to 'write off' these sciences as fatally masculinist, is likely to be related to lack of ideas for alternative methodologies emerging in these disciplines. Nevertheless, I take the view that, as there is nothing intrinsically 'masculine' about these sciences, there is no reason for why feminists cannot explore and develop new methodologies in them too. Because changes in methodology depend on a greater diversity of scientists and a commitment to creativity not seen in the present science, when more women and feminists enter the physical sciences, and the organisational changes necessary to sustain their numbers and facilitate new methodologies are implemented, feminists' development of new methodologies in the 'hard' sciences will be boosted.

Perhaps the different context of the physical science makes alternative approaches more difficult. As I have already argued there is insufficient knowledge about the relationships between the various scientific disciplines and subject areas to map the potential for similar research methodologies to be developed. Nevertheless, feminising science could involve interdisciplinary research, and collaboration more broadly. Instead of simply looking to the subject matter of the disciplines of science, it is again important to consider organisational change. Networks of feminists will also be crucial in developing interdisciplinary feminist research via facilitating cross-fertilisation of ideas. It is therefore central to the project of feminising science to re-organise science, especially to increase the numbers of women and challenge the male domain of science in all of the scientific disciplines. The next section addresses another important element: the dialectic of change within science and outwith science, in the wider society.

9.4.2 Internal and External Change

There are three main ways in which the process of feminising science is necessarily linked with changes in the wider society.

First, a more democratic science involves democratic changes in the wider society. Clearly for scientists to be properly involved in the community the community must support such involvement. At present communities' interest in science tends to arise around specific issues which might impact on them. In normal circumstances an ambivalence to science is more prevalent. Although scientists' involvement in community issues is a good way to generate a more lasting interest, this general ambivalence to science must nevertheless be tackled. More fundamentally, the notion of community must be addressed. To what extent do people feel part of a community or many communities? People require education about science, but also a stake in their community - ambivalence can be related to peoples' wider feelings of powerlessness. This is not only true about science, but all areas of the political economy. Democratisation of science cannot therefore be disassociated from more fundamental democratisation which would involve the *re-creation* of communities. Nowadays scientists tend to live in more affluent areas. Advocating their participation in their community therefore means the affluent areas will benefit, whereas the more economically disadvantaged communities will remain unaffected. A democratic science therefore requires a fairer society, ie a more equal distribution of wealth and privilege.

Second, funding for feminist research requires changes in the funding bodies and their distribution of money. This is related to the above point about democracy. For people to be involved in a meaningful way on the boards of funding bodies the elitism of the establishment must be confronted. Similarly, government priorities are directly related to the extent and distribution of science funding. Only a government with similar priorities to feminist scientists would distribute research money in a favorable way.

Third, changes in the workplace in science are related to changes in other workplaces. This, once more, requires government initiatives and legislation for change, eg proper nursery provision, paternity leave, job sharing. There is no reason to assume that science workplaces will change faster than those in other institutions.

These three examples of the inter-linking process of feminising science and changing society illustrate the need for wider political and economic change to support a feminist science. This is perhaps the greatest barrier to change. It is therefore crucial that feminist scientists support and work in collaboration with feminists and others advocating democratic change in the wider society, and vice versa.

9.4.3 Teaching Feminist Science

The third and final strategy for feminising science is teaching a feminist science. Students' naiveté about the place of women in science and the social and political factors which shape scientific knowledge was illustrated in Chapter 7. I suggest that this can be challenged by a radical overhaul of the way science is taught and, more realistically, by the promotion of courses on women in science, or women's biology, as taught by some of the feminist practitioners I interviewed.

Ideally science students would be taught to be critics of science as well as knowledge producers. Courses would involve the social and political history of science, and encourage creative thinking about how to address new, unanswered questions in science. In addition, the social responsibility of scientists would be emphasised. The development of this kind of science teaching will develop as a result of changes in the scientific community and knowledge production, outlined in section 9.4.1.

In the meantime feminists' interest and concern about teaching their students is a positive step in the right direction. Their development of courses and, more informally, their interaction with students in the teaching laboratory and classroom, contributes to students' better understanding of the nature of science.

Teaching students about the male domain of science might be an effective way of conveying the male domination of science in terms of numbers and power, in addition to addressing ways in which this shapes the practice of science, and the knowledge produced. I argued previously that this might avoid hostility to the feminist critique of science or theories about a feminist science in the case of women scientists, because it shifts the emphasis away from intrinsic differences between men and women. The same might also be true for science students.

9.5 Conclusion

In this chapter I have developed theory concerning the male domain of science as an initial step in understanding how the practice of science is gendered. This emphasises the importance of male domination and the way in which it is reinforced with the use of particular communication styles and methodologies. The importance of interactions between the male domain of science and men in other powerful social institutions, eg funding bodies and policy makers, was also discussed.

I went on to argue that the 'best version' of a feminist science is based on a commitment to ending the male domain of science. There is no one set of feminist questions and methodologies, but many. A constructive tension between understanding the social construction of scientific knowledge and a commitment to better, more objective forms of knowledge, in the sense of a commitment to more accurate knowledge, subject to peer review. A similar tension between reductionism and holism and control of, or respect for, nature was identified. Increasing the numbers of women in science and promoting organisational change which will provide a decent working environment for women scientists, in addition to promoting changes in the wider society as well as changes within science are other important, interdependent, features of this version of a feminist science. More importantly, the processes of reaching this ideal feminist science, involve an integrated approach to organisational, methodological and societal change. This constitutes a practical framework for a feminist science.

In the final chapter, which now follows, I discuss these findings in the context of the whole study, highlighting strengths and weaknesses in my approach, and areas for future research.

Chapter 10 Conclusion

10.1 Introduction

In this final chapter I address the main conclusions of Chapter 9 in the context of the thesis as a whole. In section 10.2 I reconsider the notion of science as a male domain, asking whether it solves the problems I identified in the feminist critique of science as masculine. More generally, have I provided a theory that might help to 'bridge the gap' between women scientists and feminist critics of science? Does the notion of science as a male domain have the potential to alleviate women scientists' hostility to the suggestion that science is intrinsically masculine, without losing appreciation of the subjectivity of science emphasised by feminist critics of science? I take a similar approach in section 10.3, this time addressing the 'best version' of a feminist science, in addition to the strategies for achieving such a science, suggested in Chapter 9. Do I provide sufficient detail and clarity of meaning as well as adequate consideration of how to operationalise a feminist science? In each of these sections I appraise the strengths and weaknesses of my suggested theory. In section 10.4 I move on to consider the overall methodology and research design of the thesis. I reflect on what I see as the strong points of the thesis, as well as its limitations. I discuss the notion of 'linking theory and practice' in particular, a guiding principle in my research. In section 10.5, I discuss future research areas raised by this work. I end in section 10.6 by contemplating how the process of research has changed my own thoughts and feelings about feminism, about science, and about social research.

10.2 Science is a Male Domain: a critique

I developed the notion of science as a male domain after a preliminary review of the women in science literature in Chapter 2, and the feminist critique of science as masculine in Chapter 3, followed by empirical investigation of science students' and practitioners' experience and views on gender, feminism and science. I criticised the women in science literature for implicitly accepting the notion of science as being value free. Although I recognised the pervasive association between science and masculinity, as outlined by feminist critics of science, I identified the following three problems: over-general and excessively rigid and deterministic definitions of masculinity; lack of consideration of the way in which rhetoric and practice interact; and insufficient exploration of the variety of contexts of scientific practice.

The notion of science as a male domain was an attempt to unite the understanding of sex, gender and science from these two literatures, and to overcome their weaknesses. I argue that I achieved this in three main ways. I combined the emphasis on the organisational inequalities of science in the women in science literature with an appreciation of the rhetoric of value-free knowledge from the critiques of science outlined in Chapter 3. I suggested that the way in which men in science hold influence and control is intimately tied to their perpetuation of the 'myth of objectivity'. I also argued that men's influence and control are tied to their repetitive use of particular methodologies, which often tend to be reductionist. Second, I provided a more flexible treatment of the concept of masculinity than the feminist critique of science as masculine. I argued for the notion of masculinity as a label, without losing an appreciation of its infusion through science. Moreover, I suggested that the notion of science as a male domain allows for the existence of different masculinities within science, which can change through time. I pointed out that in the male domain of science masculine influences are likely to be perceived differently by different groups concerned with gender and science, depending on their priorities. Third, I highlighted the different layers of meaning behind, and associations between, objectivity/subjectivity, reductionism/holism, and control of/respect for nature. I challenged any simplistic association between gender and these features of science and provided an appreciation of the particularity of different contexts in scientific practice. This also proved invaluable for theorising a 'best version' of a feminist science.

Nevertheless, there are two ways in which this theory of science as a male domain requires improvement. I did not adequately represent the complexity of the relationship between gender identity, gender socialisation and the construction, or rejection, of gender labels in science. This is, in part, a limitation of the research design. However, the notion of a male domain is also simplistic at a conceptual level - the interaction between gender labels on practice in science and gender labels on practice outwith science remain unaddressed. Similarly, the different type of interactions between individual male scientists and the 'masculine' culture of science was largely unaccounted for (although I did acknowledge the possibility of difference). These conceptual limitations are indications of the preliminary stage of the theory that science is a male domain. This difficulty in comprehensively theorising the links between gender, language and social practices, is faced by scholars throughout the social sciences.

A second and related limitation in the notion of science as a male domain was lack of detail about differences in scientific practice. In particular, I did not explore in sufficient depth the relationship between gender and the differing practice of scientific workers and the scientific elite, or the different approaches in pure and applied science. More generally, the focus on (mainly) biological and physical research science in UK and North American universities was limiting. Scientific practice in the private sector in contrast to the public sector, and in new and emerging disciplines in contrast to older more established disciplines, was not thoroughly explored in the thesis. A partial picture of scientific practice was therefore provided. Differences in the 'micro level' of scientific practice were also afforded limited consideration. Each research event in science is unique: the dynamics of communication in each research team will be different as will the combination of research techniques and conceptual progress.

Despite these limitations I argued that the concept of science as a male domain fulfills the criteria, raised in Chapter 1 and in more detail in Chapter 3, for 'strategic theorising', theory to bring about change (Connell, 1983). I suggested four main strategies.

1. I emphasised the organisation of science as a male domain.
2. I made the process of labelling science as masculine explicit.
3. I highlighted the way in which the myth of objectivity functions in securing male domination.
4. I drew attention to the different contexts of scientific practice.

These strategies might be useful in uniting feminist critics and women scientists to challenge the male domination of science as it incorporates themes familiar in both their arguments in a productive way.

10.3 Feminising Science: a critique

My starting point for developing the 'best version' of a feminist science was a commitment to practical change from within the existing institutions of science which does not to forfeit radicalism in this process. I emphasised the importance of generating theories about a feminist science that were based on a proper understanding of scientific practice as it is currently, and as it might be in the process of feminising science. I went on to review feminist epistemologies of science and identified four main limitations: the tension between the individual and the community in terms of who would practice a feminist science; the tension between objectivism and relativism in terms of methodology; an insufficient consideration of organisational changes necessary in feminising science; and a lack of clarity about the relationship between feminist scientists and the wider public.

I argue that the 'best version' of a feminist science which I suggested in Chapter 9 does clarify the meaning and nature of a feminist science in these four main areas, giving details about the criteria for feminist scientists; topics investigated and methodologies adopted; organisational change and the relationship between science and the wider society. I argued for the inclusion in the feminist science community of people from a diversity of backgrounds, with a variety of interpretations of feminism, but who shared a commitment to equality for women in and via science. I then readdressed my earlier critique of the feminist epistemologies of science, which treated the tension between objectivism and relativism as a problem, and argued instead that this tension is a potential strength. In my view this is an important conclusion, as although it does not provide a 'neat answer' to the question of feminist methodology, I now view neat answers as a false goal. Instead, I argue that it is both more realistic and more progressive to explore how the methodological practice of a feminist science might be richer and more diverse This depends upon recognising the tension between objectivism and relativism as productive.

The emphasis in this 'best version' of a feminist science on organisational change was another important contribution to the theory of a feminist science. This contrasts with the tendency in the majority of feminist epistemologies of science to largely ignore questions of organisation, with the notable exceptions of Nelson and Longino, as discussed in Chapter 4. In arguing that re-organisation is the 'lynch pin' of feminising science I contributed some much needed pragmatism to the project of feminising science. In a similar vein, I highlighted the interdependence of external and internal change. Although many of the organisational and broader societal changes that I suggested have proved to be, and are likely to continue to be, difficult to achieve, I prefer to view these as optimistic, rather than pessimistic, conclusions. For me, emphasis on concrete changes is more attractive because it is more transparent and therefore more achievable than the esoteric changes proposed in much of the feminist epistemologies criticised in Chapter 4.

There are two main limitations in this 'best version' of a feminist science and the suggested strategies by which it might be achieved. First, there was a lack of detail in all of the proposals for change. Criticisms like those in section 10.2 can be applied here. Both at the 'macro' and at the 'micro' level, the relationship between science and the wider society was inadequately theorised. There was a lack of detail about the relationship between the different scientific disciplines, and the potential for 'reverberation of change'. Similarly, the different ways in which feminist scientists might develop links with the local community were not thoroughly considered.

Second, and more fundamentally, there is an ambiguity about the notion of a feminist science that I do not feel I have adequately resolved in this thesis. Although I argued that the titles 'feminist methodologies' or 'feminist topics' were inappropriate I used the term feminist science, adopting Longino's formulation that a feminist science is the science that feminists do, along with an outline of the four main aspects of the practice of a feminist science which I envisaged. At the same time I also emphasised the concept of feminising science to highlight the dynamic process of changing science that is part of the feminist project. In one way these two terms are not interchangeable - feminising science is the *process* of moving towards a feminist science. Yet, in another way I have used these terms - feminist science and feminising science - interchangeably when I argued that a feminist science is a dynamic process. This slip seems to reflect a deeper tension between the goals of feminism as a dynamic project dedicated to achieving equality, but also as an idealised vision of equality. Does this signify a fundamental contradiction in feminism? I would tend to argue, as

Harding (1986) has done, that, although this is clearly a contradiction, it is perhaps a useful one . Although I am slightly uncomfortable with this type of argument as it opens the way for contradictions which *are* flaws to be viewed as positive and therefore not adequately resolved, I feel this is not the case here - it is important for feminism to be ambivalent on this issue as feminist change must be both a practical process and a vision of the future.

Despite these limitations I argue that an important strength of this version of a feminist science was the avoidance of identifying a feminist science with a small group of women practitioners who share a narrow set of views; with qualities associated with femininity; or particular research topics and methodologies. This diversity in terms of practitioners, methodologies and topics is a strength of the theory I proposed, not a weakness. It will generate a science which is integral to, and therefore potentially influential on, mainstream science; a science which is open to different approaches and therefore more creative than orthodox science; and, perhaps most importantly, a science which attracts, not turns away, scientists with similar fears and concerns to feminists. Altogether I suggest that this is a more radical agenda than a successor science project based on more restrictive definitions of practice, which risks alienation of both female and male scientists and ultimately obscurity.

10.4 Autocritique

There are five main points to the shortcomings of the study.

First, the empirical research design could not meet all of the research questions. I raised questions about language and context in addition to questions about the relationship between gender socialisation, gender identity and the construction of gender labels, which I could not answer via interviews with science students and feminist practitioners. The discourse of science - in terms of scientists' speech and writings as well as accounts of their practice - was not evaluated. The questions about male scientists' psychology, and how this interacted with the masculine culture of science, could not be answered by interviewing feminist scientists, nor did the interview schedule involve questions to male students about their psychological state. I did not adequately consider context - for example, the range of scientists I spoke to were working in a relatively limited set of fields.

A second point about the limitations of the empirical study in terms of further analysis of the theory concerns the second and third aims of the study. Because there are so few feminists in science, and no well defined community of feminist critics or practitioners of scientists, many of the questions raised in Chapter 4, concerning a feminist science, proved difficult to investigate empirically, and were therefore not fully answered. Some interviewees relied heavily on the imagination, rather than first hand experiences. This is an inherent flaw in any study that seeks to 'theorise the future' based on the present.

Third, the data obtained from the interviews with science students proved disappointing. My original intention, to use the data to criticise the feminist epistemologies, and to compare students' views depending on whether they had studied history and philosophy of science, betrays a naiveté about the impact of such teaching of students' views and about their thoughtfulness about feminism, gender and science.

Fourth, my theoretical analysis would have benefited from a more thorough treatment of the radical science and sociology of science literature. This was limited because of the extent of the feminist material, and the lack of cross referencing in the two literatures. I have the strong feeling that this work holds the key to a more rigorous understanding of the way in which the practice of science is gendered, and, consequently, more powerful strategies for change.

A fifth limitation concerns the theme of linking theory and practice. I found that my empirical investigation could not address all of the epistemological issues I raised in Part 1. Although the empirical research was limited, as discussed above, I sense that in some ways epistemological issues will always defy comprehensive empirical investigation. It may be that theory and practice are linked and separate at the same time. The link is based on the way in which our understanding of practice and our application of practice are always based on some prior theory about the social world, be that explicit or not. Epistemology teaches us that knowing is a social process. Yet, in another way, theory and practice are distinct - no theory entirely mirrors practice - all provide a partial and incomplete representation of practice because practice is so complex. This type of argument is also relevant to the discussion about the use of the terms feminising science and feminist science, as discussed in section 10.3. Feminism can be thought of as a practical project of change and a theory of an idealised practice. The way in which I have slipped between using the terms feminising science and feminist science in this thesis shows the contradictory relationship between theory and practice. I now argue that this contradiction is inevitable, but more importantly, it is a useful tension in feminism which gives a multifaceted approach to ending women's oppression. Thus, my original focus on grounding feminist epistemologies, while still a valid goal, was never going to be entirely achievable, because no theory is ever entirely grounded in practice. Moreover, my criticism of feminist epistemologies now appears excessively harsh. There is clearly a place for epistemology and idealised theories of a feminist science, which serve, in the words of one of my interviewees, as 'mirrors for reflections'.

This thesis was over-ambitious in all three aims. Not only did I seek to provide a comprehensive theory of the relationship between science and gender, and a feminist science, but also to ground that theory in an understanding of scientific practice. The level of detail required to produce such a comprehensive theory proved impossible to elicit because of the large feminist and related literatures, and the sheer complexity of gender relations, feminism and scientific practice. Moreover, the research design was limited to interviewing a relatively small number of students and practitioners.

Despite these limitations I argue that it was important for me to be over-ambitious in this thesis. My motivation to solve what I saw as an important problem was the driving force behind the entire thesis. Although I raised more questions than I provided answers to, this does not imply a fundamental flaw in either the research aims or the research design. These questions remain to be answered, and in the next section I propose some future research that might further explore the nature of gender, feminism and science. It is also important to stress that, although investigating the experiences and perspectives of feminist practitioners and students provided a partial picture, it nevertheless provided a rich and diverse account of science. Feminist practitioners' projections of a futuristic feminist science are grounded in an understanding of the current practice of science, which affords them considerable authenticity. This became the basis for some important conclusions concerning feminist criticism and practice of science. There is a need for change to a science that meets ordinary women's and men's needs, a science that is less restricted and more open to new approaches, and a science that is practised by a diverse group of scientists. The main conclusions of the thesis gave a preliminary insight into the practical processes necessary to achieve some of these changes. I offered an alternative to the psychological reductionism of theories on the masculinity of science and the utopian nature of feminist epistemologies of science. A more complex picture of the construction of masculinity in science was provided, in addition to a pragmatic approach to change. This avoided the pitfalls of abstract theorising and generated more realistic strategies for change.

The main conclusions of the thesis are also important steps towards bridging the gap between feminist activists and theorists, women scientists and feminists. I hope to have gone some way to uniting the three sets of feminist literature: on women in science, the gendering of science, and feminist epistemologies. The theory I have outlined, although basic, is strategically linked with practical activism for change. I validate the demands of liberal feminist activists and women in science in arguing for a less dismissive approach to their male colleagues and to reductionism and control- the butt of much feminist criticism. I ask for more openness to the ideas of social construction of science and gender on the part of women in science in return.

10.5 Future Research

I propose four main avenues of future research that would be useful in generating a better understanding of how the practice of science is gendered, and strategies for feminising science.

First, in my view a thorough consideration of the interaction between language, masculinity and practice would make an important contribution to the theory of gender and science. This would require detailed contents analysis of scientific writings, formal speeches and ordinary conversation in different scientific disciplines (obtained through observational research), and would be backed up with interviews with scientists.

Second, a detailed examination of the links between individual male scientists' ego and the 'masculinity of science', which was not possible in my thesis, could usefully explore the relationship between gender, identity and rhetoric. Whilst I have rejected what I view as the over reliance on psychological explanations in the feminist critiques of science and have taken an alternative approach, in an attempt to balance the psychological interpretation, by highlighting other ways in which gender relations operate in science, I do not entirely reject a role for psychology in explaining gender relations in science. However, I argue that a major flaw in the psychological accounts is their lack of empirical justification and tendency to produce grand claims about male scientists' psychological needs. This could be usefully explored empirically, via interviews with scientists, and be united with work on discourse suggested above, along with the notion of the male domain of science which I have suggested, to move towards a more detailed theory of gender relations and science.

Third, ethnographic study of the practice of science, would surely be most useful for answering questions concerning the ways in which science is gendered in practice, in particular whether women and men do science differently. My own feeling is that a proper ethnography would be a powerful source of information. For example, the detailed work of anthropologist Sharon Traweek (1988) provides a fascinating account of the culture of high energy physics. This could be supplemented by work on other scientific sub-communities, including feminist ones. Although time consuming and expensive, ethnography would provide invaluable empirical material on women, gender, feminism and science.

Fourth, there is a real need for a proper integration of mainstream sociology of science studies and feminist studies. Much of the work in science studies involves careful empirical investigation which could be a major contribution to understanding the role of gender in scientific practice. Furthermore, the sociology of scientific knowledge could be a valuable resource. The relativistic position of the theorists in this field, although frustrating for feminists, does not negate SSK scholars' work, which is again, full of empirical *evidence.* I am not suggesting that feminists simply, 'add gender and stir', merely that they treat this literature as a resource for more rigorous theories. I would argue that the present use of psychoanalytic theories and complex epistemologies in the feminist literature, seriously weakens feminists' analysis of gender, feminism and science, which would be strengthened by a more thorough look at social relations.

Ultimately these approaches, theoretical and empirical, could be linked, to provide a more detailed understanding of gender and science and a stronger practical framework for a feminist science.

10.6 Epilogue

Throughout the three and a half years it has taken me to complete this thesis, my idea and attitudes to feminism, science and social research have altered in a number of ways. My interpretation and appreciation of feminism have consolidated around a firm belief in practical steps to achieve sexual equality. I have come to realise that feminism need not involve rejection of 'masculinity', and that men can be valuable allies in the fight for equality. Nevertheless, I have also become more tolerant of idealistic and utopian feminist theories as I see them as having a useful function in helping feminists to think more deeply about their aims and objectives. My initial reaction against the restrictive teaching practices of natural science, which led me to leave the field in favour of the social sciences, has also been replaced by a more mature and respectful attitude to the natural sciences. Speaking to feminist practitioners as part of this research made me remember the immense enjoyment that can be found in pursuing an answer to a physical problem. In a way I regret leaving physics because of this enjoyment, and also because every women who leaves physics leaves behind an even smaller network of women physicists. But I am sure that my disciplinary change was the right decision for me personally. Although I have found working on this PhD immensely frustrating at times, I do not think I would ever have completed it if I did not find social research extremely fulfilling and inherently fascinating. I have learned the importance of constantly challenging the pre-suppositions and background beliefs that I have held when doing the research, particularly beliefs about men and women, and masculinity and femininity. Thus the importance of honest and self-reflexive theorising has become clear to me. At the same time I have experienced the difficulty in being thoroughly reflexive. This has led me to appreciate the goals and difficulties which feminists in the natural sciences and the social sciences share, and therefore to doubly value the time I spent as part of this research with feminists involved with the natural sciences. Although I recognise the immense task ahead of feminists in all of the academic disciplines, and in the wider community, I hope that the spirit of collaboration which is so important in the 'best version' of a feminist science which I have suggested, continues to inform my own and other feminists' future research.

Bibliography

Abir-Am, P. & Outram, D. (eds) (1987) *Uneasy Careers and Intimate Lives: Women in Science 1789-1979* (Rutgers University Press, New Jersey, USA)

Appel, T. (1994) 'Physiology in American Women's Colleges The Rise and Decline of a Female Subculture' *Isis* 85: 26-56

Barinaga, M. (1993) 'Is there a female style in science?' *Science* Vol 260, 16 April 1993: 384-91

Barnes, B. (ed) (1972) *Sociology of Science: Selected Readings* (Penguin Books, London)

Barnes, B. (1974) *Scientific Knowledge and Sociological Theory* (Routledge and Kegan Paul, London)

Barnes, B. (1977) *Interests and The Growth of Knowledge* (Routledge and Kegan Paul, London)

Barnes, B. & Edge, D. (eds) (1982) *Science in Context: Readings in the Sociology of Science* (Open University Press, Milton Keynes)

Barnes, B. (1988) *The Nature of Power* (Polity Press, Cambridge)

Belenkey, M., Clinchy, B., Goldberger, N., & Turule, J. (1986) *Women's Ways of Knowing: The Development of Self, Voice and Mind* (Basic Books, NY)

Ben-David, J. (1960) 'Roles and Innovation in Medicine' *Americal Journal of Sociology*, 65: 557-68

Benson, M. (1982) 'Feminism and the critique of scientific method', in Miles and Finn (1982), 47-66

Bielby, W. (1991) 'Sex Difference in Careers. Is science a special case?' in Zuckerman et al (1991), 108-125

Billard, L. (1992) 'The Influence of Gender on Advancement in Astronomy, Physics and Mathematics' in Urry et al. (1992), 23-44

Bindman, L. Brading, A. & Tansey, T. (1993) *Women Physiologists* (Portland Press, London)

Birke, L. (1986) *Women, Feminism and Biology* (Methuen, NY)

Birke, L. (1992a) 'In pursuit of difference: scientific studies of women and men', in Kircup and Keller (1992), 81-102

Birke,L. (1992b) ‘Transforming biology’, in Crowley, H. & Himmelweit, S. (1992), 66-77

Bleier, R. (1984) *Science and Gender: a critique of biology and its theories on women* (Pergamon Press, New York and London)

Bleier, R. (ed) (1986) *Feminist Approaches to Science* (Pergamon Press, New York and London)

Bloor, D. (1973) 'Wittgenstein and Manheim on the Sociology of Mathematics' *Studies in History and Philosophy of Science* 4: 173-91

Bloor, D. (1976) *Knowledge and Social Imagery* (Routledge and Kegan Paul, London and Boston)

Boston Women’s Health Collective (1969) *Our Bodies Ourselves* (Simon and Schuster, NY)

Brighton Women and Science Group (eds) (1980) *Alice Through the Microscope: the power of science over women's lives* (Virago, London)

Burrows, A. (1992) Review of Zuckerman et al, *Social Studies of Science,* Vol 22: 581-5

Butler, J. (1990) *Gender Trouble: Feminism and the Subversion of Identity* (Routledge, New York)

Caldecott, L.& Leland, S. (eds) (1983) *Reclaim the Earth: Women Speak Out for Life on Earth* (The Women's Press, London)

Chodorow, N. (1978) *The Reproduction of Mothering* (University of California Press)

Ciccotti, G., Cini, M., & De Maria, M. (1976) ‘Poduction of Science in Advanced Capitalist Society’ in Rose and Rose (1976a), 32-58

Cockburn, C. (1981) 'The Material of Male Power' *Feminist Review* 9: 41-59

Cockburn, C. (1983) *Brothers: male dominance and technological change*(Pluto Press, London)

Cockburn, C. (1985) *Machinery of Dominance: women, men and technical know-how* (Pluto Press, London)

Cole, J. & Zuckerman, H. (1987) 'Marriage, Motherhood and Research Performance' *Scientific American* Vol 256: 83-89

Collins, H. (1974) 'The TEA Set: Tacit Knowledge and scientific Networks', *Science Studies* 4: 165-186

Collins, H. (1981) 'The Place of the "Core-Set" in Modern Science: Social Contingency with Methodological Propriety in Science' *History of Science* 19: 6-19

Collins, P. H. (1986) 'Learning from the Outsider Within: The Sociological Significance of Black Feminist Thought' *Social Problems* 33: 14-32

Connell, R. (1983) *Which Way is Up?* (Allen and Unwin, London)

Connell, R.(1987) *Gender and Power* (Polity Press, Cambridge)

Cowan, R. S. (1995) 'Women and Science: Contested Terrain', in *Social Studies of Science*, Vol 25: 363-370

Cox, C. (1992) 'Eco-feminism', in Kircup and Keller (1992): 282-293

Crane, D. (1972) *Invisible Colleges; A Diffusion of Knowledge in Scientific Communities* (University of Chicago Press, Chicago)

Crowley, H. & Himmelweit, S. (1992) *Knowing Women: Feminism and Knowledge* (Polity Press/OU, Cambridge/Milton Keynes)

Daly, M. (1978) *Gyn/Ecology: The Meta-Ethics of Radical Feminism* (Beacon Press, Boston)

Department of Education (1990) *University Statistical Record Vol 1 Staff and Students*

Dworkin, A. (1981) *Pornography: Men Possessing Women* (The Women's Press, London)

Easlea, B. (1978) *Liberation and the Aims of Science* (Chatto and Windus, London)

Easlea, B. (1981) *Science and Sexual Oppression* (Weidenfeld and Nicholson, London)

Eichenbaum, L. and Orbach, S. (1984) *What Do Women Want?* (Fontana, Glasgow)

Ezrahi, Y. (1971) 'The Political Resources of American Science' *Science Studies* 1: 117-33

Fausto-Sterling, A. (1985) *Myths of Gender: biological theories about women and men* (Basic Books, NY)

Fausto-Sterling, A. (1992) 'Building Two-Way Streets: the Case of Feminism and Science *National Women's Studies Association Journal* 4, 3: 336-349

Fee, E. (1982) 'A feminist critique of scientific objectivity', *Science for the People* vol 14, 5-8: 30-33

Fee, E. (1983) 'Women's nature and scientific objectivity', in Hubbard and Lowe (1983), 9-28 (also published in *International Journal of Women's Studies)*

Fee, E. (1986) 'Critiques of Modern Science: the Relationship of Feminist to Other Radical Epistemologies' in Bleier (1986), 42-56

Firestone, S. (1971) *The Dialectics of Sex* (Paladin, London)

Flax, J. (1983) 'Political Philosophy and the Patriarchal Unconscious: A Psychoanalytical Perspective on Epistemology and Metaphysics,' in Harding and Hintikka (1983), 245-282

Flax, J. (1987) 'Postmodernism and Gender Relations in Feminist Theory'. *Signs: Journal of Women in Culture and Society* 12, 4: 621-43

Flax, J. (1990) *Thinking Fragments: Psychoanalysis, Feminism and Postmodernism in the Contemporary West* (University of California Press, Berkeley, CA)

Foucault, M. (1973) *The Birth of the Clinic: an archeology of medical perception* (Pantheon, NY)

Fox, M. (1991) 'Gender, Environmental Milieu and Productivity in Science' in Zuckerman et al (1991), 188-204

Fox, W. (1989) 'The Deep Ecology-Ecofeminism Debate and its Parallels' *Environmental Ethics* Vol 11 Part 1: 5-25

Franklin, S., Long, C. & Stacey, J. (eds) (1991) *Off Centre: Feminism and Cultural Studies* (Harper Collins, London)

Franklin, U., Gay, H. & Miles, A. (1993) (guest editors) 'Women in Science and Technology: the Legacy of Margaret Benson', *Canadian Woman Studies* ,Winter 1993, Vol 13, no2 (University of York Publications)

Friedan, B. (1963) *The Feminine Mystique* (Dell, NY)

Gilbert, G. & Mulkay, M. (1984) *Opening Pandora's Box: a Sociological Analysis of Scientists' Discourse* (Cambridge University Press)

Gillespie, B. Eva, D., & Johnston, R. (1982) 'Carcinogenic risk assessment in the USA and UK: The case of Aldrin/Dieldrin' in Barnes and Edge (1982), 303-336

Gilligan, C. (1982) *In a Different Voice: psychological theory and women's development* (Harvard University Press, Cambridge MA)

Grant, L., Ward, K. & Forshner, C. (1992) 'Mentoring Experiences of Women and Men in Academic Physics and Astronomy' in Urry et al. (1992), 81-88

Gray, E. (1981) *Green Paradise Lost* (Roundtable Press, Wellesley, Mass)

Griffin, S. (1984) *The Roaring Inside Her* (The Women's Press, London)

Habermas, J. (1971) 'The Scientization of Politics and Public Opinion', in *Towards A Rational Society*: 62-80

Haraway, D. (1979) 'The biological enterprise: sex, mind and profit from human engineering to sociobiology' *Radical History Review*, 4: 21-36

Haraway, D. (1985) 'A Manifesto for Cyborgs: Science, Technology and Socialist Feminism in the 1980's' *Socialist Review* No 80, 65-108

Haraway, D. (1986) 'Primatology is Politics by other means,' in Bleier (1986), 77-118

Haraway, D. (1987) 'Animal Sociology and a Natural Economy of the Body Politic, Part 1: A Political Physiology of Dominance' in Harding and O'Barr (1987), 217-232

Haraway, D. (1988) 'Situated Knowledge: *The Science Question in Feminism* and the Privilege of Partial Perspectives' *Feminist Studies* 14: 575-599

Haraway, D. (1989) *Primate Visions* (Routledge, NY)

Haraway, D. (1991) *Simians, Cyborgs, and Women* (Routledge, NY)

Harding, J. (ed) (1986) *Perspectives on Gender and Science* (Falmer Press, Brighton)

Harding, S. & Hintikka, M. (eds) (1983) *Discovering Reality: feminist perspectives on epistemology, metaphysics, methodology and philosophy of science* (Reidel Publishing, Dordrecht, The Netherlands)

Harding, S. & O'Barr, J. (eds) (1987) *Sex and Scientific Inquiry* (University of Chicago Press)

Harding, S. (1986) *The Science Question in Feminism* (Cornell University Press, Ithical, NY)

Harding, S. (1991) *Whose Science? Whose Knowledge? Thinking From Women's Lives* (OU Press)

Harding, S. (1993) 'Comments on Anne Fausto Sterling's "Building Two Way Streets"' *National Womens' Studies Association Journal* , 5, 1: 49-55

Hartsock, N. (1983) 'The feminist standpoint: developing the ground for a specifically feminist historical materialism,' in Harding and Hintikka (1983), 283-310

Hartsock, N. (1984) *Money, Sex and Power: Towards a Feminist Historical Materialism* (University of Masachusetts Press, Ameherst MA)

Hass, V. & Perrucci, C. (eds) (1984) *Women in Scientific and Engineering Professions* (University of Michegan Press, Ann Arbour)

Hekman, Susan (1990) *Gender and Knowledge* (Cambridge, Polity)

Hesse, M. (1980) *Revolutions and Reconstructions in the Philosophy of Science* (Harvester Press, Brighton)

Hornig, L. S. (1984) 'Women in science and engineering: why so few?' *Technology Review* vol 87, no 8 (Nov/Dec): 31-41

Hirsch, M. & Keller, E. (eds) (1990) *Conflicts in Feminism* (Routledge, London)

Hubbard, R. & Lowe, M. (1979) *Genes and Gender II: Pitfalls in Research on Sex and Gender* (Gordian Press, NY)

Hubbard, R., Henifin, S. & Fried, B. (eds) (1979) *Women Looking at Biology Looking at Women* (Schenkman Publishing Co., Cambridge, MA)

Hubbard, R., Henifin, S. & Fried, B. (eds) (1982) *Biological Woman - The Convenient Myth* (Schenkman Publishing Co., Cambridge, MA)

Hubbard, R. & Lowe, M. (eds) (1983) *Women's Nature: rationalizations of inequality* (Pergamon Press, NY)

Hughes, T. (1983) *Networks of Power Electrification in Western Society* (John Hopkins University Press, Baltimore)

Irwin, A. (1994) 'Star Woman', *Times Higher* March 25, 1994

Jacobus, M. (1982) 'Is there a woman in this text?' *New Literary History* 14: 117-41 reprinted in Jacobus, M. (1986) *Reading Woman: Essays in Feminist Criticism* (Columbia University Press, NY)

Jacobus, M., Keller, E. & Shuttleworth, S. (eds) (1990) *Body/Politics Women and the Discourses of Science* (Routledge, London)

Jagger, A. (1983) *Feminist Politics and Human Nature* (Rowman and Allenheld, Totowa, NJ)

Jasanoff, S., Markle, G., Petersen, J. & Pinch, T. (eds) (1994) *Handbook of Science and Technology Studies* (SAGE)

Jensen, K. B. & Janowski, N. (1991) (ed) *A Handbook of Qualitative Methodologies for Mass Communication Research* (Routledge, London)

Kahle, J. B. (1985) *Women in Science: a report from the field* (Falmer Press, Brighton)

Keller, E. (1978) 'Gender and Science' *Psychoanalysis and Contemporary Thought* 1(3): 409-33

Keller, E. (1982) 'Feminism and Science', *Signs*, 7: 589-602

Keller, E. (1983) *A Feeling for the Organism: the life and work of Barbara McClintock* (W. H. Freeman, NY)

Keller, E. (1985) *Reflections on Gender and Science* (Yale University Press, New Haven CT)

Keller, E. (1986) 'How gender matters, or, why it's so hard for us to count past two,' in Harding, J. (1986)

Keller, E. (1987a) 'The Gender/Science System: or is Sex to Gender as Nature is to Science', *Hypatia*, vol 2 no3: 37-49

Keller, E. (1987b) 'Learning About Women: Gender, Politics and Power' *Daedalus* Journal of the American Academy of Arts and Science 116, 4: 77-91

Keller, E. (1987c) 'Feminism and Science' in Harding and O'Barr (1987), 233-246

Keller, E. (1990) 'From Secrets of Life to Secrets of Death', in Jacobus et al (1990), 177-191

Keller, E. (1992a) 'How gender matters or why it's so difficult to count past two,' in Kircup & Keller (1992), 42-56

Keller, E. (1992b) *Secrets of Life, Secrets of Death* (Routledge, NY)

Keller, E. (1994) 'The Origins and Politics of the Subject Called "Gender and Science": A First Person Account' in Jasanoff et al (1994), 80-94

Kelly, A. (1981) *The Missing Half: girls and science education* (Manchester University Press, Manchester)

Kelly, A. (1987) *Science for Girls?* (Open University Press)

Kheel, M. (1985) 'The Liberation of Nature: A Circular Affair', *Environmental Ethics* Vol 7 Part 2: 135-149

Kimball, (1981) 'Women and Science: A Critique of Biological Theories', *International Journal of Women's Studies*, 4, 4: 318-338

King, L. , Dixon, V. & Nobel, W.(eds) (1976) *African Philosophy: Assumptions and Paradigms for Research on Black Persons* (LA, Fanon Centre Publications, Charles R Drew Postgraduate Medical School)

Kircup, G. & Keller, L. S. (eds) (1992) *Inventing Women: Science, Technology and Gender* (OU Press)

Knorr-Cetina, K. (1981) *The Manufacture of Knowledge: An Essay on Constructivist and Contextual Nature of Science* (Pergamon Press, Oxford and New York)

Knorr-Cetina, K & Mulkay, M. (eds) (1983) *Science Observed: Perspectives on the Social Study of Science* (SAGE Publications, London)

Kuhn, T. (1962) *The Structure of Scientific Revolutions* (University of Chicago Press, Chicago)

Latour, B. (1987) *Science in Action* (Open University Press)

Latour, B. & Woolgar, S. (1979) *Laboratory Life: The Social Construction of Scientific Facts* (Sage, Beverly Hills, 2nd edn. Princeton UP, 1986)

Longino, H. (1988) 'Science and Feminist Values' *Feminist Studies* 14, 3: 561-574

Longino, H. (1989) *Science as Social Knowledge* (Princeton University Press)

Longino, H. & Doell, R. (1983) 'Body Bias and Behaviour' *Signs* 9, 2: 206-27

Longino, H. & Hammonds, E. (1990) 'Conflicts and Tensions in the Feminist Study of Gender and Science' in Hirsch & Keller (1990), 164-183

Lowe, M. (1993) 'To Understand The World in Order to Change It', *Canadian Woman Studies*, Winter 1993, 13, 2, 6-11

MacRae, S., Devine, F. & Lakey, J (1991) *Women in Engineering and Science: Employer's Policies and Practices* (Policy Studies Institute, London)

Marcy, G. and Elmergreen, D. (1992) 'University Approaches to Affirmative Action' in Urry at al. (1992), 107-116

Martin, E. (1989) *The Woman in the Body: A Cultural Analysis of Reproduction* (Beacon, Boston)

Martin, E. (1991) 'The Egg and the Sperm: How Science has Constructed a Romance Based on Stereotypical Male-Female Roles' *Signs* 16, 3: 485-501

Merchant, C. (1980) *The Death of Nature: women, ecology, and the scientific revolution* (Harper and Row, San Francisco)

Merton, R. (1942) ' Science and technology in a democratic order' *Journal of Legal and Political Sociology* vol 1, republished as 'Science and democratic social structure' in *Social Theory and Social Structure* (1967) (Free Press) also republished as 'The Institutional Imperatives of Science' in Barnes (1972)

Miller, J. (1972) 'The Dog Beneath the Skin', *The Listener* (London) (20 July): 74-76

Miles, A. and Finn, G (eds) (1982) *Feminism in Canada* (Black Rose Books, Montreal)

Mitchell, J. (1974) *Women and Psychoanalysis* (Penguin, Harmondsworth)

Mitchell, J. & Oakley, A (1986) (eds) *What is Feminism?* (Blackwell, Oxford)

Mulkay, M. (1979) *Science and the Sociology of Knowledge* (George Allen and Unwin Ltd, London)

National Research Council (1994) *Women Scientists and Engineers Employed in Industry, Why so Few?*

National Science Foundation (US) (1990) *Women and Minorities in Science and Engineering*

Nelkin, D. (1982), 'Controversy as a political challenge', in Barnes and Edge (1982), 276-281

Nelson, L. (1990) *Who Knows; From Quine to a Feminist Empiricism* (Temple University Press, Philadelphia)

Nicholson, L. (1990), 'Introduction' in Nicholson (ed) (1990), 1-16

Nicholson, L. (ed) (1990) *Feminism/Postmodernism* (Routledge, London and New York)

Oakley, A. (1972) *Sex, Gender and Society* (Temple Smith, London)

O'Brien, M. (1981) *The Politics of Reproduction* (Routledge and Kegan Paul, Boston)

Office of Science and Technologies' Working Party on Women, Science and Engineering (1993) *Realising Our Potential: The 1993 White Paper on Science, Engineering and Technology* (HMSO)

Office of Science and Technologies' Working Party on Women, Science and Engineering (1994) *The Rising Tide: Women in Science* (HMSO)

Packer, K. 'Climbing the career ladder? The position of women and girls in UK science and technology', presentation at Science Policy support Group Policy analysis Forum *A Gender Policy for British Science* 10th May 1993

Powney, J. (1994) 'The Context of Gender Research in Education', paper presented at *Gender and Education Research Network*, Glasgow Caledonian University, Cowcaddens, Glasgow, 23/4/94

Price, D (1963) *Little Science, Big Science* (Columbia University Press, NY)

Provine, W. (1973) 'Geneticists and the Biology of Race-Crossing' *Science* 182 (23 November): 790-96

Quine, W. V. (1960) *Word and Object* (Cambridge Mass: MIT Press)

Ravetz, J. (1971) *Scientific Knowledge and Its Social Problems* (Clarendon, Oxford)

Restivo, S. (1983) *The Social Relations of Physics, Mysticism and Mathematics; Studies in Social Structures, Interests and Ideas* (D. Reidel Publishing Company, Dortrecht)

Richards, E. & Schuster, J. (1989) 'The Feminine Method as Myth and Accounting Resource: A Challenge to Gender Studies and Social Studies of Science', *Social Studies of Science,* 19: 697-720

Rose, H. (1983) 'Hand, Brain and Heart: A Feminist Epistemology for the Natural Sciences' *Signs* 9: 73-90

Rose, H. (1986) 'Women's Work: Women's Knowledge.' in Mitchell and Oakley (1986), 161-183

Rose, H. (1994) *Love, Power and Knowledge: towards a feminist transofrmation of the sciences* (Polity, Cambridge)

Rose, H. & Rose, S. (1969) *Science and Society* (Penguin, Harmondsworth)

Rose, H. & Rose, S. (eds) (1976a) *The Political Economy of Science* (MacMillan, London)

Rose, H. & Rose, S. (eds) (1976b) *The Radicalisation of Science* (MacMillan, London)

Rose, S. (1976) 'Scientific Racism and Ideology: The IQ Racket from Galton to Jensen' in Rose & Rose (1976a), 112-141

Rosser, S.(1990) *Female Friendly Science: applying women's studies methods and theories to attract students* (Pergamon Press, Oxford)

Rossiter, M. (1982) *Women Scientists in America: Struggles and Strategies to 1940* (John Hopkins University Press, Baltimore)

Rousseau, G. & Porter, R. (eds) (1980) *The Ferment of Knowledge: Studies on Historiography of Eighteenth Century Science* (Cambridge University Press)

Ruddick, S. (1989) *Maternal Thinking: Towards a Politics of Peace* (Beacon Press, Boston)

Savan B. (1988) *Science Under Seige. The Myth of Objectivity in Scientific Research* (Routledge and Kegan Paul)

Science Policy Support Group (SPSG) *Women in Science Newsletter* (1994) Vol 11 March/April 1994

Segal, L. (1987) *Is the Future Female? Troubled Thoughts on Contemporary Feminism* (Virago Press, London)

Shapin, S. (1980) 'Social Uses of Science' in Rousseau and Porter (1980), 93-142

Shapin, S. (1982) 'History of Science and its Sociological Reconstructions', *History of Science,* 20, pp. 157-211

Shepherd, L. (1993) *Lifting the Veil: The Feminine Face of Science* (Shambala, London)

Skidmore, L. (1992) 'Women in Science: Past and Future Trends in Women and Astronomy' in Urry et al. (1992), 45-56

Smith, D. (1987) *The Everyday World as Problematic: A Feminist Sociology* (Northeastern University Press, Boston)

Sørensen, K. (1992) 'Towards a Feminized Technology? Gendered Values in the Construction of Technology' *Social Studies of Science,* 22: 5-31

Spender, D. (1980) *Man Made Language* (Routledge and Kegan Paul, London)

Spender, D. (1984) *Time and Tide Wait for No Man* (Women's Press, London)

Spender, D. (1982) *Women of Ideas (and What Men Have Done to Them)* (Routledge and Kegan Paul, London)

Star, S. (1979) 'Sex Difference and the Dichotomising of the Brain: Methods, Limits and Problems in Research on Consciousness', in Hubbard & Lowe (1979),

Stepan, N. (1982) *The Idea of Race in Science: Great Britain 1800-1960* (Archon Books, Hamden, CT)

Tobias, S. (1992) 'The "Problem" of Women in Science' in Urry et al. (1992), 73-80

Traweek, S. (1984) 'High Energy Physics: a male preserve', *Technology Review*, 87, 8 (Nov/Dec): 42-3

Traweek, S. (1988) *Beamtimes and Lifetimes: The World of High Energy Physics* (Harvard University Press, Cambridge MA)

Traweek, S. (1989) *Particle Physics Culture* (Harvard University Press, Cambridge MA)

Tuana, N. (ed) (1989) *Feminism and Science* (University of Indiana Press, Bloomington, IN)

Urry, C. M., Danly, L., Sherbet, L. E. & Gonzaga, S. (1992) *Women in Astronomy*; Proceedings of a workshop held at the Space Telescope Science Institute, Baltimore, Maryland, USA, September 8-9 1992.

Warren, K. (1987) 'Feminism and Ecology: Making Connections' *Environmental Ethics* 9, Part 1: 3-20

Williams, R. & Edge, D. (forthcoming) 'The Social Shaping of Technology', *Research Policy*

Wynne, B. (1982) 'Natural knowledge and social context: Cambridge physicists and the luminous ether' in Barnes and Edge (1982), 212-232

Zimmerman, M. (1987) 'Feminism, Deep Ecology, and Environmental Ethics' *Environmental Ethics* 7, Part 1: 21-44

Zuckerman, H., Cole, J. & Breuer, J. (eds) (1991) *The Outer Circle: Women in the Scientific Comminity* (W W Horton, NY)

Appendix 1 Student Interview Schedule

Part A: Experience of Traditional Science

(1) Background in science.

(2) Reasons for studying/not studying philosophy of science course and assessment of the course.

(3) Have you experienced or witnessed an~~d~~y androcentric or sexist bias in the practice of science? Show interviewee List 1.

(4) Is there any difference in the way that males and females do science? Refer to List 2 and 3. Where a difference is identified ask for elaboration.

(5) If not already mentioned by interviewee, are there any males or females who do not fit in with their generalisations?

(6) What might be the reason for any differences identified?

Part B: Opinions and Attitudes

(1) What qualities are important in science? Refer to List 4.

(2) Did HPS change attitude to science, particularly objectivity and fact in science?

(3) Can the scientific method eliminate bias if properly applied?

(4) Would more women in science encourage stricter attention to sexist bias?

(5) What is required to eliminate bias? A radical transformation, acceptance of subjective nature of knowledge?

(6) Is science masculine?

(7) Is a feminine science more or less acceptable?

Part C: Feminist Theories of Science

(1) What is a feminist science? Is it feasible, desirable?

(2) If studies HPS criticism of feminist theories?

(3) Would a feminist science be more feminine?

(4) Is a feminist science possible without a feminist society?

(5) See description sheet

(i) What should be the role of bias in a feminist science? Can it be eliminated or used 'properly'?

(ii) Problems with either approaches?

(iii) What does it mean for physics?

(6) Would a feminist science be better than science as it is now?

(7) Would women do science better under a feminist science?

(8) How should a feminist science be taught?

List 2: Practice of Science in the Laboratory

(1) Research Problem

(i) Is there a gender difference in problem definition or selection?

(ii) For example, is either sex more likely to:

* participate in military research?
* propose hypotheses to explore problems of social concern?
* participate in work outwith traditional specialist boundaries?
* give more weight to gender in the research question?

(2) Method and Design

(i) Is there a sex difference in the methods and design of experiments?

(ii) For example, is either sex more likely to:

* adopt a holistic, interactive approach?
* include their own subjectivity in the research?
* adopt an interdisciplinary approach?
* include the personal experience of the subjects or objects of research?

(3) Observation

(i) Is there a difference in how men and women observe when performing and experiment?

(ii) For example in:

* observing interactive relationships or relationships where one constituent dominates over the other?
* spending more time observing?

(4) Conclusions

(i) Is there a difference in the conclusions men and women draw from the data?

(ii) For example in:

* use of gender neutral language in describing data and presenting theories?
* criticising their own observations?
* awareness of sexist biases that might permeate theories and conclusions?

(5) General Approach

(i) Are there any other, more general, differences in the way men and women do science?

(ii) For example in:

* integrating their role as scientist with other aspects of their personal life, or to think of their role as scientist as the most important aspect of their life?
* their preference for small-scale research with small pieces of equipment or large scale research with large, sophisticated equipment?
* a preference for working in a group, or alone?
* creativity, inventiveness, intuition, accuracy, patience?
* engagement in social or political aspects of their work?
* empathy with other scientists and with their subjects?

* adoption of a holistic, interactive approach, involving their own subjectivity or objectivity?
* confrontational interactions with other scientists?
* competitiveness, aggression, practicality?
* concern with controlling nature?

List 3: Learning and Knowing Science

(1) Is there any difference in the way that men or women think about science?

(2) For example in

* working with abstract theory or with practical examples?
* ability in the use of abstract thought, or practicality?
* use of machine metaphors or more natural ones?
* use of memory?
* creativity or inventiveness when solving problems?
* originality of thought?
* intuition?
* questioning of information?
* preference for working alone or in a group?

List 4: Qualities Important in Science

* Creativity
* Intuition
* Accuracy
* Practical sense
* Ability to withstand adversity
* Inclusion of subjectivities and context
* Complex, interactive models
* Dominant constituent models
* Inventiveness
* Patience
* Theoretical Skills
* Co-operation
* Objectivity
* Inter-disciplinary approach
* Specialisation
* Ability to work alone

* Ability to work in a group
* Respect of nature's complexity
* Concern with own career
* Questioning

* Empathy
* Control of nature
* Engagement in social and political issues
* awareness of bias

Appendix 2 Lists and References

List 1: Stages in the Practice of Science

Funding

(a) commissioning and Funding of Research

Research Methods

(b) definition of experimental problem

(c) hypothesis

(d) research questions

(e) experimental design

(f) method of data collection

(g) data used and ignored

(h) interpretation of data

Dissemination of Results

(i) research report

(j) publishing

(k) conference presentation/discussion

(l) teaching

List 4: Qualities Important in Science

* Creativity
* Intuition
* Accuracy
* Practical sense
* Ability to withstand adversity
* Inclusion of subjectivities and context
* Complex, interactive models
* Dominant constituent models
* Ability to work in a group
* Respect of nature's complexity
* Concern with own career
* Inventiveness
* Patience
* Theoretical Skills
* Co-operation
* Objectivity
* Inter-disciplinary approach
* Specialisation
* Ability to work alone
* Empathy
* Control of nature
* Engagement in social and political issues

Feminist Science Theories

There are two main approaches to bias in feminist epistemology of science. The first can be called **feminist empiricism.** This argues that feminists should aim to **eliminate bias through rigorous attention to the scientific method** combined with a thorough examination of all the biases that could be present in the research. **Women should become more involved in science** to 'police' sexist bias.

The second, **feminist standpoint theory**, argues that to discuss bias in science in misleading, as it implies there is such a thing as a neutral, unbiased position. This is rejected on the grounds that **all knowledge is grounded by the standpoint of the knower**, all knowledge is biased. **Feminist scientists should do science from a feminist perspective** ie. with the explicit political aim of emancipating women. More generally, sexist and other discriminatory biases should be revealed through a thorough examination of all scientists' standpoints.

A key point about **feminist standpoint theory** is that it is argued that **women's position as the oppressed provides a better vision of reality** than the dominant group's vision which is partial, and distorted by their power and desire to maintain that power. It is argued that women's principle role as caretaker in the home 'grounds' their understanding in reality. This provides a better basis for science than 'abstract masculinity'.

Reference Sheet for Student Interviews

Bias

Sexist Bias - eg. not **funding** research by women; an experimental **hypothesis** that women are less intelligent than men; not **publishing** articles by women

Androcentric Bias - eg. not **funding** research that looked at the **female experience**; experimental **hypothesis** that looks at the **male experience** and takes it to represent the **female experience**; not **publishing articles about women**

Approach, Aims and Method

Objectivity - unbiased, impersonal, open-minded, detached approach.

Inclusion of own subjectivity/Self Reflexivity - a recognition of the inevitability of one's own biases and prejudices entering the science one does and the consequent commitment to investigate and give details of how this shapes one's approach and results.

Empathy - involves a sense of **respect, connectedness and sympathy** with both humans and mature which is carried through into one's work as a scientists; eg. this might involve concern with the effects of one's work on the environment, a rejection of laboratory experiments on animals, science which aims to liberate humans from oppression.

Control of nature - science which aims to **harness nature to serve man's needs; to disempower nature** where it threatens man's power eg control of disease, provision of power sources, sophisticated shelter, communication etc. This can also imply control of other groups associated with nature - women and black people eg sociobiology (where it is argued that women's destiny is in their genes, for example, they are genetically programmed to be home makers); population control.

Holistic, interactive method - to look at the whole complex web of relationships between variables via non-interventionist observation eg. observation of chimpanzee society in the field.

Reductionist, interventionist method - to isolate and study one variable whilst holding the others constant, and to take an active role in setting up the experiment and manipulating variables eg. laboratory experiments on chimpanzee sociability via isolation of individuals compared with a control group of chimpanzees confined together.

Models and Metaphors

Interactive models - a model based on how each constituent in a given system interacts with the others eg. Barbara McClintock's theory of genetic transposition in DNA where DNA is in a delicate interaction with the cellular environment and control of cellular development resides in the complex interaction of the whole cellular system.

Dominant constituent models - a model of constituents where one dominates in relationships with the others and is taken to be the most important constituent eg. Watson and Crick's 'master molecule' model of DNA where DNA encodes the vital information of the cell and dominates cellular development and information flows one way from DNA to RNA protein.

Machine metaphors - models based on machinery which are used to build theories based on machine-like structure and individual parts combined together eg. the human body has been modelled on a machine since the 18th century.

Natural metaphors - models based on nature; involving complexity; unpredictability; interacting functions eg. chaos theory, 'organic' organisational structures.

Appendix 3 Student Talk

(1) Introduction

Thank those who have agreed to participate in interview.

Outline:
explain briefly what purpose of research is;
describe interview;
outline some issues and concepts that will be discussed;
details of follow-up.

(2) Purpose of Interview

My history - physics degree. Part of research at University of Edinburgh into gender and science, and linking feminist theory about science with the practice of science. Interested in scientists' and science students' experience of and attitudes to science and feminism. Important aspect of the research that I am dealing with here is the role of philosophy of science courses in shaping students' attitudes to science, particularly feminist science. Look at male and female students in zoology and physics who have studied philosophy of science and equal numbers of those who have not.

(3) Describe Interview

Interview about an hour long, tape recorded if permission given. Split into 2 parts: experience and opinions and attitudes. Mixture of open-ended and more specific questions - sometimes use lists or examples to help. Note that there is no right or wrong answer - interested in everyone's' interpretation and opinion. I have no vested interest in hearing a particular answer.

(4) Outline of Issues and Concepts

Before interview look at some of the main ideas in the feminist literature to set the scene for some of the things will discuss and give an opportunity to ask questions about what the interview will cover. Note these are an outline of some feminist ideas, and not necessarily mine.

Deal first with more liberal feminist claims about science and then move on to consider more radical claims.

Liberal Claims

Science is sexist

Science is androcentric (male-centred)

This kind of science is bad - can be corrected by stricter adherence to scientific methods and more women into science to 'police' sexist bias. Use scientific arguments to disprove sexist theories.

Examples:

Sexist bias in science might involve not funding research by women or a hypothetical experiment that women are less intelligent than men; or not publishing articles by women.

Androcentric bias might be not funding research about women or funding interest of prime interest to men and not women (space research, military research); or not publishing articles about women.

An example of feminist response to sexist theory is in feminist research into the validity of theories that link sex difference in mathematical and visual spatial ability with hormonal levels, Here feminists challenge the theory on the grounds that the evidence used to justify it was not related to sex difference. Kimball claims that although the major piece of evidence used - the more testosterone present the better the males do in simple, repetitive tasks - 'does tell us something about the relationship of hormones to certain kinds of cognition in males it tells us nothing about sex difference, the differential strengths of the two hormones (oestrogen and androgen) or the effect of oestrogen on female cognitive function' (Kimball, 1981). There is also no definite evidence of a link between female oestrogen levels and cognition.

More Radical Claims

Science is sexist and androcentric but it is an inherent feature of science which can only be challenged by radical reorganisation. Use ideas of Evelyn Fox Keller.

Normal science is masculine science. This involves objectivity, control of nature, reductionism and an interventionist approach. Definitions:

objectivity - impersonal, detached, unbiased

control of nature - to harness man's needs; to disempower where man's needs are threatened. nb use of word man deliberate.

reductionism - one variable is examined whilst the others are held constant.

interventionism - to actively intervene, to manipulate.

This is seen by Keller as a masculine endeavour because of the division between emotional and intellectual labour.

Barbara McClintock example - a cytogeneticist who was marginalised in mid-career but eventually recognised and awarded a Nobel prize. McClintock, Keller argues, had a particular methodological approach, which was different from the prevailing one. This involved an emphasis on intuition, connectedness and relatedness, in fact Keller entitles her biography of McClintock *A Feeling for the Organism.* So, in contrast to the masculine science that Keller outlines, McClintock's methods involve her own subjectivity (thoughts and feelings) not objectivity; empathy with nature, not control; and an emphasis on holism (the complex web of variables) rather than reductionism; and a non-interventionist approach - 'letting the material speak'.

Keller uses these theories to explain the theory of DNA that McClintock developed and to compare it with another masculine theory of 'Master Molecules' that Watson and Crick developed. Here DNA is the master molecule, encoding the vital information of the cell and dominating cellular development. In contrast, McClintock's theory of genetic transposition offers a more holistic view, characterising DNA in delicate interaction with the cellular environment, where control of cellular development resides in the complex interaction of the whole cellular system.

Any questions?

(4) Follow Up

Hope to have a discussion session once everyone is interviewed (for about half an hour). This is to see if ideas have changed and to see if they change when you have a discussion. Again, there is no right or wrong answer.

Intend to send transcripts of interviews and receive feedback.

Set up interview times.

BACK UP EXAMPLES FOR STUDENT INTERVIEWS

(i) Biological Research on Sex Hormone Influence on Human Behaviour (from Longino, 1989)

Consider pre-natal influence on 'gender role' behaviour; pre- and post-natal androgens (male hormones) and female homosexuality; low androgen levels in male at puberty and spatial abilities.

Criticised for the following:

(a) assumption that there is a linear relationship between data and theory, ie. a one-way causal relationship between hormones and later cognition and behaviour;

(b) androcentric bias in what counts as data (2 sexes and genders); description of lesbianism and designation of 'appropriate' gender roles; and background assumptions - male mathematical superiority;

(c) uses evidence from relationships in other mammals to support finding - ignores the difference between species;

(d) 'indicates a willingness to look at human beings in a particular way - to see us as produced by factors over which we have no control ... prisoners of our psychology. In the name of extending an explanatory model, human capacities for self-knowledge, self-reflection, self-determination, are eliminated from any role in human action (at least in behaviour studies)' (Longino, 1989, p52).

(ii) A Feminist Alternative might mean:

(a) a replacement of the linear models with one of greater complexity involving physiological, environmental, historical and psychological factors;

(b) this would allow for interactions between these factors and with the central processing unit (CPU) and allow for self- modification, self-representation; self-organisation;

(c) this more complex model will show the relevance of the intentional states of the brain; it is based on an ideology of self-determination - a main ten~~an~~et of feminist research is the valorisation of the subjective (the personal is political). Feminists are not waiting on the data to speak (avoiding the unconscious hangover of traditional bias) but actively fashioning research which is consistent with their wider political aims and commitments;

(d) note that complex models and not necessarily always better than linear ones; in this case they are preferred for political reasons, not because they are an expression of 'women's' nature'.

Appendix 4 Interview Script for Practitioners

1 Background

1.1 What are your research interests and what is your present position?

1.2 What is your scientific background? How did you get to where you are now?

1.3 How did you become interested in women and science or issues of gender and science? Have your ideas about this changed as time has gone on? For example, would you say you had become more or less radical?

2 Alternative Science

2.1 What would your 'ideal science' be? Would the culture of science, the methods, the subject areas and/or the role of the scientist be different from what it is now?

2.2 How do you feel about extending your ideas of science from your own discipline to the whole of science?

2.3 What are the main barriers to your ideal science?

3 Feminist Science

3.1 Do you consider yourself a feminist? What does that mean to you?

3.2 How do you take your feminism into your science?

3.3 What does a feminist science mean to you? Do you believe that a feminist science is desirable? Is it possible?

3.4 Do you think that there is a point to trying to develop and outline of what a feminist science might be?

4 Feminist Critique of Science

4.1 How masculine do you think orthodox science is? Are, for example, objectivity, reductionism and specialisation, masculine? What would a feminine science be? Is it desirable?

4.2 Do men and women do or know science differently? For example organisation of laboratory, teaching, publishing? Do men and women look at different problems/subjects in science; perform an experiment differently; get different results? Are women more holistic and men more reductionist? If you think there's a difference - why?

4.3 Do you think 4.1 and 4.2 are relevant questions when considering what a feminist science would be?

5 Feminist Science Theories

5.1 How interested are you in the feminist theories about science? Do you think they're relevant to science? Which theorie(s) do you prefer and why? Which theories do you dislike and why?

5.2 What do you think of feminist theories eg. Sandra Harding's, Donna Haraway's and Evelyn Fox Keller's work?

5.3 Do you think there's any particular aspect of any of the feminist theories that's 'doable' in science? Could you 'do' 'strong objectivity' (Sandra Harding) or 'situated knowledge' (Donna Haraway)? Is there anything that's especially inapplicable?

5.4 Do you think there's a difference in theories that come from feminist scientists and those that come from feminist philosophers?

5.6 Do you think feminist philosophers should be trying to speak to scientists, trying to change science and make it more feminist? Or, does their work serve other purposes?

t